SMITH'S ILLUSTRATED ASTRONOMY.

THE 2d TELESCOPE IN SIZE IN THE UNITED STATES, AT THE CINCINNATI OBSERVATORY.

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A NIGHT IN AN OBSERVATORY.

At this serene season, when the nights are generally clear, and the air is beautifully transparent, there is no more delightful recreation than to spend a night in an astronomical observatory. The cool breeze that springs up after sundown; the free, open expanse of the fathomless heavens, with their countless glittering points, which are as familiar to the astronomer, who calls them all by their names, as the coast lights to a sailor; the quiet that reigns around enhanced by the mild gleam of star light replacing the dazzling, flaring, fussy, spluttering illuminations in which the noisy world plies its tasks; the unfamiliar and wonderful side of nature that is unfolded to the view; the expansion of which the mind is conscious in dealing with spheres and distances that make the huge earth we tread appear like a mere crumb—all these things give a refreshing sense of freedom from ordinary cares, and an inspiriting desire to know more of this vast universe of suns and worlds in which we dwell. The discoveries of astronomy have abolished the old distinction between the heavens and the earth. We know that the earth flies in the heavens, and is as much a member of the heavenly host as any star. So far as our knowledge goes, all the worlds and suns that surround us are composed of materials similar to those which make up this globe, and even the ether filling space is probably no more than a very rare atmosphere which, condensed about the earth, furnishes us with the breath of life.

If we suppose that our night in an observatory begins with the earliest shades of evening, the first foreign world that our eyes light upon will be Venus. Before the sunset spectacle is ended Venus begins to peep through the colored curtains of the west. This is the best time to view her with a telescope, both because she soon sinks so low that the mists of the horizon interfere with clear vision, and because the twilight robs her of some of the glare which always surrounds this brilliant planet, making it perhaps the most difficult of all telescopic objects. Still, Venus is exceedingly beautiful in the telescope, especially during the crescent phase upon which she will soon enter. During the autumn the smallest telescope will show Venus as a crescent. In telescopes of considerable power she looks in certain parts of her orbit so much like the new moon that persons unaccustomed to such observations have actually been deceived and supposed they were looking at the moon when they were really looking at Venus. At present Venus resembles the moon near the first quarter.

Mars is not far from Venus now, but is not well situated for telescopic observation.

We turn, therefore, to the stars, and the first that catches our eye is the splendid Arcturus, celebrated in all ages as the chief twinkler of the north, and singled out by name from all the starry host in the Book of Job, when the Almighty speaks out of the whirlwind. Arcturus is a copper-colored star, and is seen sinking in the northwest early in the evening. In the telescope it glows with extraordinary beauty, and its peculiar color shows to advantage. It is, beyond doubt, many times larger than our sun, and it possesses great heating power, which can be detected with proper instruments. The telescope shows a multitude of small stars forming a cluster around it. Above Arcturus we see the pretty half-circle of stars called the Northern Crown, and a little to the right of a line joining Arcturus, and the brightest star in the crown, is the celebrated Epsilon Boötes. Nobody ever looked at this star through a powerful telescope without a cry of admiration. It is composed of two stars so close together that it is a severe test for a small telescope to separate them. But when sufficient power is employed to throw them apart, there they shine bright as diamonds, one rich orange in color, the other pure sea-green, almost touching one another, and seeming to vie in beauty. It has been shown that these stars are really connected, that they revolve around a common centre, and so the worlds upon which they shine have two suns, one of the hue of a blood orange, and the other as green as an emerald.

Our astronomer next calls our attention to a very beautiful star which is shining almost directly overhead between 8 and 9 o'clock. It is white, with a trace of blue in its scintillations. This is Vega in the Harp, a star that almost equals Arcturus in size and exceeds it in beauty when seen
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for telescopes of m
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Vega is so remark
omer whether th
difference in the n
"Yes," he replie
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minute star we see two, well separated, each a great deal brighter than the single one was to the naked eye, while a third faint star appears a little to one side.

"Now I will put on a higher power," he says.

We look again, and behold, each of the two twinkling diamonds we saw before is composed of two stars clinging close together, like cherries on a stem. Between the two pairs two other faint stars seem to have sprung into being. The wonder of it is that these stars belong together, revolving around one another at a distance, probably, of many million miles, and yet they are so far away from us that the whole system of revolving suns is blended, to the naked eye, into a dimly shining point of light.

"Now for a change we will look at a nebula," says the astronomer. He points the telescope, by means of its right ascension and declination circles, upon a spot in the heavens south of Vega, which appears to be utterly black and empty. But the powerful instrument reveals a strange thing in those black depths. It is an oval ring of nebulous light hanging there in empty space like a wreath of smoke. It looks as though a breath would blow it into nothingness, but our whole solar system, placed within that ring, would appear as a mere speck. It used to be thought that the ring was composed of stars until Mr. Huygens tried his spectroscope upon it and found that it is gas—not gas in the sense in which we ordinarily understand the word, but the chaotic material out of which suns and worlds are made.

East of Vega is the beautiful constellation of the Northern Cross, and the astronomer pauses to show us the star Albireo in the foot of the Cross, which is really composed of two stars, one yellow, the other deep blue. The Milky Way, streaming southward from the Cross, becomes very brilliant in the constellation Sagittarius, near the southern horizon; and, as the telescope is slowly swept along its course, the sight is wonderful beyond expression. Everywhere the milky light is resolved into a bed of stars strewn as thick as silver dust, here congregating in globular and irregular masses, there spread out into a fretwork of sparkling points. Suns and suns, everywhere a countless multitude of them, yet this is only the threshold of the universe. In the southwest we see the long, crooked constellation of the Scorpion, whose chief twinkler is Antares, a sun in whose fiery rays is hidden a little green star only visible with a good telescope.

As the night wears on and Arcturus sinks below the horizon, the Pleiades and Aldebaran are seen rising in the east, and with them rises Saturn. It takes a sharp eye to see distinctly seven stars in the Pleiades, but the telescope shows a swarm of stars of all sizes, from the beautiful Alcyone down to mere dust.

Aldebaran, which marks the eye of the Bull, is a celebrated star, of great use to navigators. Its color, which can be readily distinguished by the unassisted eye, is peculiar—a pale rose, unlike the hue of any other star. The astronomer, putting a high power on the telescope, calls our attention to a faint speck of light which seems to be following in its wake.

We pass over Saturn, and Jupiter, which rises an hour or two later, to continue our exploration of the stellar heavens.

At midnight we see rising slowly in the northeast one of the most magnificent stars in all the heavens—Capella. Here we have a sun which, according to the spectroscope, closely resembles our own in composition. But it is very much larger than our sun, which removed to the distance of that splendid star would appear faint indeed. Capella shines with a soft creamy light, very different from the white rays of Vega. Above Capella is
s, with its celebrated cluster, looking like
white cloud to the naked eye, but re-
by the telescope into a swarm of stars,
south of Perseus the astronomer shows
ol, or the Winking Demon, a star that,
he mysterious reason, suddenly becomes
int, and then, in a few hours, flashes out
splendor again. This is repeated fifteen
in every forty-three days.
o'clock Orion is rising. This constella-
as no rival in splendor. Its two chief
between which it is difficult to award pre-
e, are Betelgeuse, a topaz-colored gem,
on's shoulder, and Rigel, as white as the
diamond, on his foot. Betelgeuse is ex-
gly beautiful in the telescope, but Rigel
s more attention because it has a small
ompanion star. The amateur astrono-
mer feels well satisfied with his telescope if it is able to reveal this little star amid the flashing rays of Rigel, and he searches for it, taking advantage of every favorable moment when the air is steady, and turning the focussing screw with the most delicate touch, as eagerly and skilfully as the sportsman, armed with rod and flies, tempts a sly trout from his hiding place in some shady pool. There are a great many fine double stars in Orion, and in his sword is the famous nebula. It is worth sitting up a whole night to get a look at that nebula, wherein, unless astronomers are mistaken, we see suns and worlds in process of formation.

Under Orion's feet is the little constellation of the Hare, which our astronomer tells us contains one of the most singular objects in all the sky. He turns the telescope upon it, and we behold what seems to be a drop of blood suspended in mid space. It is a little star as red as red can be made. No artist, however skilful, could imitate the purity of its hue. Yet we are assured that that blood-red star is a sun as large, perhaps, as our sun, and that inhabited worlds may be revolving in its crimson blaze. What a marvellous universe is this of which we are all citizens!

At last, as the clocks are striking 4, and the rattle of the milkmen's carts begins to awaken the homeless sleepers in street corners, Sirius, the king of stars, appears blazing on the horizon. One look at him through the telescope, which blinds the eye for five minutes afterward, and a glimpse of his strange companion, which seems to be the gigantic ember of an almost burned-out sun, and we bid the astronomer good morning.

SIGHTS WITH A TELESCOPE.

Saturn a Baby World, though 700 Times as Large as the Earth—Jupiter Magnified Two Million Times—The Mysterious Companion of the Dog Star—The Great Nebula.

The great blue dome of the Halstead Observatory rising boldly above the lofty walls of gray stone, which lift it out of the dust and smoke of the little town, is the most striking edifice in Princeton. It gives an air of erudition to the place. The traveller seeing it confronting him as he alights at the railroad station feels at once that he is in a university town, where the gravity of learning lends unwonted weight and dignity to all things, even to the chanticleer who, somewhat haughtily, though gravely and decorously, eyes him from a neighboring fence without indulging in any unscholarly and unmannerly crowing. One can imagine the Spaniards looking with something like awe upon the returned ships of Columbus. A great observatory seems to produce a similar effect. The magical charm of discovery hovers around it—discovery not among continents and islands on the other side of the earth, but among suns and worlds soaring in the heavens, many of which are far grander and more glorious than our own.

The new telescope which has recently been mounted in the observatory at Princeton is, with the exception of the one in Washington, the largest in this country. Its object glass lacks but one inch of being two feet in diameter, and the cigar-shaped tube of steel is about thirty feet long. It ranks with the half dozen telescopic giants which within a few years have been placed in the hands of the astronomers of the world, but of whose astonishing achievements the public has heard but little. Sir William Herschel would have thrown away his big reflectors in disgust if he could have caught a glimpse of the heavens through one of these telescopes. People who are not familiar with the progress of astronomy have no notion of work that is being done in the great observatory overlooking the battle-ground of Princeton—work that is changing the whole outlook for the
human mind: bring the earth
into communication with its neighbors
heavens, as steam engines and the tel
have linked together the four quarters of
globe. People generally have no conce
what modern astronomers have done
Take, for instance, their studies
Mars. If it were told of some ancient
it would be set down as an idle fable, yet
fact that our astronomers to-day have a more
comprehensive knowledge of the geography of
Mars than anybody in the time of Columbus
had of the geography of the earth. They have
made careful maps of the whole planet
filled with astonishing details, and if a
astronomer were suddenly transported to
Mars and set down at some given point
upon its surface, he would not, by any
means, feel that he was lost. Given his latitude and longitude, he would know that in a
certain direction and at a distance of a certain
number of miles lay the body of water named
in his maps the Lake of the Sun, or Lockyer
Sea, and that in another direction was the
continent of Copernicus. He would know
whether he was standing upon an island or
mainland, what the general shape of the land
was, and which was the shortest route to the
sea coast. If the inhabitants of Mars were
inclined to maritime enterprise and geographical exploration, he would be able to tell them
more than they had ever known of the
form and position of the lands and seas
of their globe, and might, perhaps, earn
a comfortable living in a strange world by
opening a school for instruction in earth
geography. These same astronomers have not
only weighed the sun and discovered of what
materials it is composed, but they have also
analyzed the stars and shown that in many of
them the same elements exist with which we
are familiar on earth. They have proved that,
so far from our sun being the only one, the
universe is sprinkled with many millions of
suns. They have found that worlds and suns
go through a process of development, and by
looking at the spectrum of a star they can tell
whether it is probably older or younger than
the sun. They have discovered suns some
larger than ours, which, grouped together
in pairs and by threes and fours, are
swinging around a common centre. They have
found spots in the heavens that are fairly
bedded and ablaze with suns. With them
one may look upon chaos itself for they tell
that the so-called gaseous nebulæ are
portions of the universe which have not
been organized into solar systems.

In view of these facts, an account of
wonderful scenes which are opened to
celestial spaces by the great Princeton
scope, and which are seldom enjoyed by
body except an astronomer, must possess
terest for all readers. The Princeton telesc
is particularly interesting, because it is
charge of one of the foremost of living astr
omers, Prof. C. A. Young, who has made so
of the most important additions to astrono
cal science which it has received in mod
times. An amateur astronomer, who rece
spent an evening in the Princeton observat
tells this story of what he saw:

"We began with Saturn. I have often stu
Saturn with a small telescope, and have ne
known a person to look at that planet for
first time, even with such an instrument
not a cry of surprise and admiration. Bu
Saturn, as shown by the Princeton telesco
was a revelation to me. Think of a glo
almost 700 times as large as the earth su
pended in space in the middle of three or fou
concentric rings, which are nearly 40,000 mi
broad and more than 400,000 miles in circu
but less than 100 miles thick, and turned edg
wise toward the planet's equator! This tr
mendous ringed world, together with the eight
moons that revolve around it, appears to the
naked eye only as a dull-looking star; but
imagine it brought so near that its gl
alone appears many times larger tha
the full moon, while all its surroun
ings are equally magnified, and you
have some notion of the power of the great
escope. The question naturally arises in
mind of the observer, "Is it possible that th
marvellous planet can be inhabited?" It
easy for the imagination to picture the appear
ance of those rings as seen from different
points on Saturn, here shining as enormo
ares of light, and there hiding the sun an
burying a large portion of the planet in the
shadow. There is some curious evidence tend
ing to show that the rings are falling, or rath
being drawn down toward the planet, and th
in three or four centuries they will touch it an
eventually fall to pieces, as it were, thus rob
bing the heavens of one of the strangest phe
nomena that man has ever looked upon. If
Saturn were inhabited, what a tremendous
event the destruction of the rings would be for
the inhabitants to look forward to! But
it seems to me that the revelations of
this monster telescope show plainly enough
that Saturn is not yet inhabited. Everybody knows that modern astronomers generally
regard Saturn, together with Jupiter and the
other larger planets, as not yet being cooled
down and permanently crusted over like the
earth. Geologically they are many ages younger
than the earth. They are yet in a fiery and
perhaps partly vaporous condition. But the
effect of the mere reading of such statements
bears no sort of proportion to that produced by
actually looking upon a world which has not
yet cooled down. As I gazed at Saturn I saw
how the earth probably looked ages before man
was created, when it was 'without form and
void,' and when 'darkness was upon the face
of the deep.' It was a startling as well as a
intensely interesting thing to be thus brought
face to face with what [illegible] genesis of a world
to be enacted [illegible] the formation of
gesses which are [illegible] hinted at
Bible history of how [illegible] beginning
future oceans are [illegible]

its atmosphere, tossing and heaving with a motion that is all but perceptible in the telescope. I was not fortunate enough to witness anything of the kind, but at times great telescopes have shown the distortions in the planet's outline produced by the heaving of the vast sea of vapor surrounding it. Its future continents, yet burning hot, or perhaps mere expanses of liquid fire, are hidden beneath a veil of steam and smoke. But when it is ready to receive and nourish living beings, what a magnificent world it will be! All the earth's dozen hundred millions of inhabitants would hardly more than suffice to people one of its islands. 'How many millions of years,' I asked myself, 'will pass before a race resembling man begins to explore Saturn, to settle it and cultivate it, to build cities and fleets there? It would be a flight worthy of a new Dædalus to reach the rings.'

"'Look at Enceladus,' said Prof. Young.

"The remark was so pat with the line of thought I had been following that for a second I half expected to see the old Titan of that name, who made war on the gods when the earth was young, preparing to renew the fight in this new world of Saturn. But the astronomer was not talking of demi-gods, but of the little moon named Enceladus, which hovers close under the wing of the ringed planet, and is only visible with such giant telescopes as this. It is one of the eight moons that will adorn the sky for future lovers in Saturn to swear by.

"We next turned the great tube on Jupiter, a still more gigantic planet than Saturn, though less wonderful, because it has no rings. Here I saw another world in its fire age. But there are indications that Jupiter, geologically considered, is older than Saturn; that is to say, further advanced toward the condition in which the earth now is. This conclusion, I think, is warranted by the appearance of Jupiter's surface, which contains many more conspicuous markings and spots than are seen on Saturn, and some of these spots remain almost unchanged for years. An ordinary telescope generally shows only two dark belts running along on each side of the planet's equator, a few spots, and the bluish tinge of the surface around the poles. The Princeton telescope shows that the whole huge ball is covered, and, in the neighborhood of the equator, crowded with belts, spots, and streaks. Jupiter's atmosphere, like Saturn's, is filled with clouds which present a most picturesque appearance. I regretted very much that the famous red spot which appeared on Jupiter in the summer of 1878 has faded almost to invisibility within a few months. This giant telescope would, perhaps, have thrown some light upon the nature of the spot. But I saw enough to convince me that Jupiter has not yet developed into a habitable globe. With Saturn, Uranus, and Neptune, it forms a family of giant worlds which will in time bloom with life. That will be the age of great worlds, as this is the age of little worlds. Life will there, perhaps, assume forms of which we have never dreamed.

"When the old hulk we tread shall be a wreck,
A slag, a cinder, drifting through the sky,
Without its crew of fools.

"Irrespective of the suggestions which it conveyed, Jupiter was a superb object, worth a long journey and the loss of a whole night's sleep to see. It hung before the eye, an enormous globe—not a flat disk, but round and full, and perceptibly bulged in the equatorial region through the effect of its rapid rotation. It was like taking a station off in space and watching the earth rotate, only Jupiter rotates much faster than the earth. In an hour you could plainly perceive how the great planet had rolled on its axis, spots that had been near the edge being advanced toward the centre, while new spots had come into sight along the edge of the ball. The shades, tints, and markings on the huge globe were indescribable. On each side of the equator was a great belt, the northernmost one being a pinkish red, while the southern belt was grayish. A delicate shade of pink was the prevailing color on both sides of the equator, and this beautiful background was diversified with light and dark spots and streaks. Rows of spots resembling the snowy white "thunderheads" that are often seen poking above the horizon as the advance guard of a summer storm flecked the surface in some places. A man must be destitute of all power of imagination not to see in some of these spots unmistakable clouds, and in the darker spots adjoining them the shadows which they cast. Beyond the irregular main belts which seemed to border the equatorial regions were other belts and spots without number running far up toward each pole, but around the poles the surface was shadowed with a tint recalling the lighter shades of a fine steel engraving. At times, when the air was particularly steady, all the delicate details of the planet's surface came out exquisitely defined. Once Prof. Young put on a magnifying power of 1,440 diameters which means that the surface of the planet was magnified more than two million times! The atmosphere was not steady enough to give good definition with such a power, but the gigantic and startling appearance of the planet, distorted and blurred by the tremendous magnifying, as it seemed to the observer (by the unsteadiness of the air, in fact), and the flickering forms of the belts and spots showing dimly like huge shadows, made a sight that I shall never forget.

"Below the well-known Belt of Orion everybody who watches the brilliant skies of our winter nights must have noticed a hazy-looking star. It is the famous Great Nebula. Very little telescopic power is required to show it as a luminous cloud through which stars are shining. But it is difficult to convey to one who has not beheld it with his own eyes an idea of the magnificent appearance of this nebula when seen with such a telescope as that at Princeton. The whole field of view, with the higher powers, is filled with a shining green haze broken up into flocculent masses, delicate clouds of light, sprays and wisps. It is sprinkled with stars which glitter like diamonds in a bride's veil. It looks as though you could scatter it with a breath, but it fills a space, in comparison with which the solar system is a mere point. Many astronomers believe it consists of the stuff of which suns and worlds are made, and some think appearances can be detected in it which indicate that it is at this moment being moulded into suns. One of the triumphs achieved by the late Henry Draper was the photographing of this nebula, and his photographs may enable future astronomers to determine just what changes are taking place, and whether in this strange object we really do behold the slow development of a new domain of solar systems. There is a black gap at one point in the nebula, and in this gap shine the four stars constituting the well-known trapezium. There are two other stars near these which small telescopes do not show. This is the central point of interest in the nebula. It seems clear that those stars are not there by accident, but that there is a real connection between them and the nebula. They appear, as Prof. Young remarked, to be feeding upon the nebula.

"From the Great Nebula we turned to Sirius, or the Dog Star, the brightest of all the stars. It is easy to believe that the stars are suns when one looks at Sirius through a two-foot object glass. It dazzles the eye like ten thousand stars combined into one. Yet a man must have faith in mathematics to believe that Sirius is a sun at least a thousand times as great as our sun. If the earth were as near to Sirius as it is to the sun it would be burned to a cinder in a moment. But, to me, the most interesting thing about this great star was its mysterious companion, the discovery of whose existence is one of the triumphs of modern telescopes. There it shone with a dull, pale, ghostly light, almost hidden in the overpowering rays of the star. In bulk it almost equals Sirius himself, and they swing around one another like two giants who have grappled upon an icy footing. Prof. Young says the companion is rapidly approaching Sirius. But what is it? We can hardly call it a sun, for it has not the light of a sun. It may be the ember of a sun that is dying out. It may be one of those strange dark bodies with which space, it is believed, abounds, and which, having fallen within the attraction of Sirius, is dogging it through the sky. You know that the stars are all in motion—Sirius, as the spectroscope shows, is moving away from us at the rate of twenty miles a second—so that it is easy to conceive that the star may have came across its dusky companion in this way. The laws of gravitation will never let them part, though the distance between them may vary; and so the greatest sun of which we have any knowledge must go swinging through space with its skeleton comrade until it itself becomes cold and dark. The greatest interest for us in all this lies in the possibility that our own sun may at some time, as it journeys on, fall within the attraction of one of these dark cosmical bodies and so come to have a companion like Sirius. The disturbing force of a body, having a mass equal to, or greater than that of the sun, and brought into the neighborhood of the solar system, would produce changes in the motions of the planets which might render the earth uninhabitable.

"I cannot stop to tell of what else the great telescope shows in the star depths; how it reveals shining beds of stars in the Milky Way; how, when turned upon a nebulous speck, it sometimes shows the astonished observer a veritable ball of stars, an innumerable multitude collected into a globular cluster, and at other times reveals thousands of stars arranged in spraying lines, and spirals, and all odd shapes. When I visited the observatory the moon was not in a favorable phase for telescopic study, but I know what the big telescope would do with the moon. It would reveal the ragged mountains and craters, the tablelands, like those splendid ones surrounding the Bay of Rainbows, the peaks, and the old ocean beds with a distinctness that would make the startled observer fancy some supernatural power had suspended him directly above that old worn-out world preparatary to letting him drop down to perish in one of its airless and waterless wildernesses, or to be battered and crushed in the rocky bottom of one of its extinct craters. If I had such a telescope, I fear, though bound to this terrestrial dust-mote, I should spend my life in other, grander worlds."

THE SKY A CEMETERY.

"I HAVE been watching the star called the Winking Demon," said the astronomer, as he extended his hand to pull the reporter up on the roof. "These autumn mornings are a little chilly, but the air is so deliciously pure and clear that one doesn't mind if it bites a little. Beside, it is worth the risk of catching cold to see the Demon wink. You are just in time to watch him as he gradually reopens his eye. If you had come a few minutes earlier you might have seen him shut it."

"Where is this remarkable demon star?"

"There, almost overhead at this hour. If you want to point him out to your friends you have only to observe that he is a little south of that bending row of stars that marks the constellation Perseus, and that there is a little group of smaller stars near him. Now, you see, his light is pretty faint, but not so faint as it was a few minutes ago. In three or four hours his eye will be wide open again, and he will shine as a star of the second magnitude. These winkings of Algol, or the Demon, occur a little oftener than once in three days."

"What causes them?"

"Ah, now you come to the strangest thing of all. Is there anything in the appearance of the sky, all glittering with stars, that suggests to your mind that it may be a vast cemetery? No, ridiculous! you say. Very well. You will not suppose that the earth we tread is, from one point of view, only a great burying ground, which contains the remains not only of countless generations of men, but of whole races and tribes of various animals and plants. Just so in the heavens about us the dead are mingled with the living. It is to my mind the most suggestive discovery of modern astronomy that the universe is full of dead suns—suns whose light has gone out, whose fires have been extinguished, and which no longer shed life-giving and life-preserving rays upon the worlds that may be imagined yet circling in coldness and gloom about them. What has this to do with the Winking Demon? Why, everything. I believe it is generally conceded, though Prof. Newcomb seems to dissent, that the variations in the light of Algol are caused by some huge dark body revolving around it at a frightful rate of speed. There are other variable stars whose phenomena can be accounted for in the same way. In the case of Algol there is evidence that the dark body is rapidly approaching the star, drawing nearer with every circle. When it strikes, if it is to strike, who can picture the extent of that catastrophe? Then, indeed, that mysterious dark body will become visible, blazing with the light of a hundred suns, and unable to escape from the fiery destruction that it has brought upon the star."

"Are there any other dark bodies like this known to astronomers?"

"Oh, yes; the great star Sirius is accompanied by a huge body of the kind. It is not altogether dark, for with large telescopes it can occasionally be seen glimmering faintly close to the star. Astronomers knew it was there before they got a glimpse of it, for it caused disturbances in the proper motion of the star. Another of these dark bodies which astronomers are sure exists, although no human eye ever saw it, is dogging the star Procyon, one of the brightest in the sky. You may see the star now low down in the east, north of Sirius and below the Twins. The invisible body that hovers about it is evidently of large size, for it causes considerable perturbation in the star's motion. It may once have been a sun as brilliant as Procyon itself, but now not a ray comes from it. Still, astronomers can point out the changes in its position, as its attraction pulls the star now this way and now that.

"If space is filled with these mysterious dark bodies, collisions between them and living, or light-giving, suns are not impossible. You know that our sun is in rapid motion, carrying his family of worlds along with him in his flight. So all the stars are instinct with motion. Our lives are so short and their distances are so great that we can hardly appreciate these motions, yet they are swift beyond comprehension. Some of the stars are approaching, others receding, all moving in some direction. The constellations whose forms are so familliar to us are falling to pieces like card houses. In a few thousand years there will be no Great Dipper, no Orion with his club, no Southern Cross. The heavens would look like a new universe to one of us who revisited the earth in the ten-thousandth century. Now, if we suppose that there are as many dark or dead suns as there are living ones, it is not difficult to believe that occasionally there might be collisions between them. Of course, the chances against any such collision would be very, very great, and yet some of the cases of stars that have suddenly blazed out with astonishing brilliancy and then disappeared may be accounted for in this way. To show you that there is no exaggeration in what I am saying about the multitude of dead suns in the universe, see what Sir John Lubbock said in his inaugural address at the meeting of the British Association in August last:—

"'The floor of heaven is not only "thick inlaid with patines of bright gold," but studded also with extinct stars, once probably as brilliant as our own sun, but now dead and cold as Helmholtz tells us that our sun itself will be some seventeen million years hence.'

"But we need not wander off in space in search of the sky's untombed dead. We have right at hand, circling about our own earth, not an extinct sun, but a dead world. The moon is dead, and has been dead three million years. There the astronomer, if he fancies himself the world's surgeon, may study the effects of a malady that no surgery could cure. Even worlds and suns, like men and women, grow old and die, but unlike men and women, they have no grave but the open and boundless heavens."

SUBJECTS FOR THOUGHT.

NOTHING is more reprehensible and thoroughly wrong than the idea that a woman fulfills her duty by doing an amount of work far beyond her strength. She not only does not fulfill her duty, but she most signally fails in it, and the failure is truly deplorable. There can be no sadder sight than that of a broken-down, over-worked wife and mother—a woman who is tired all her life through.

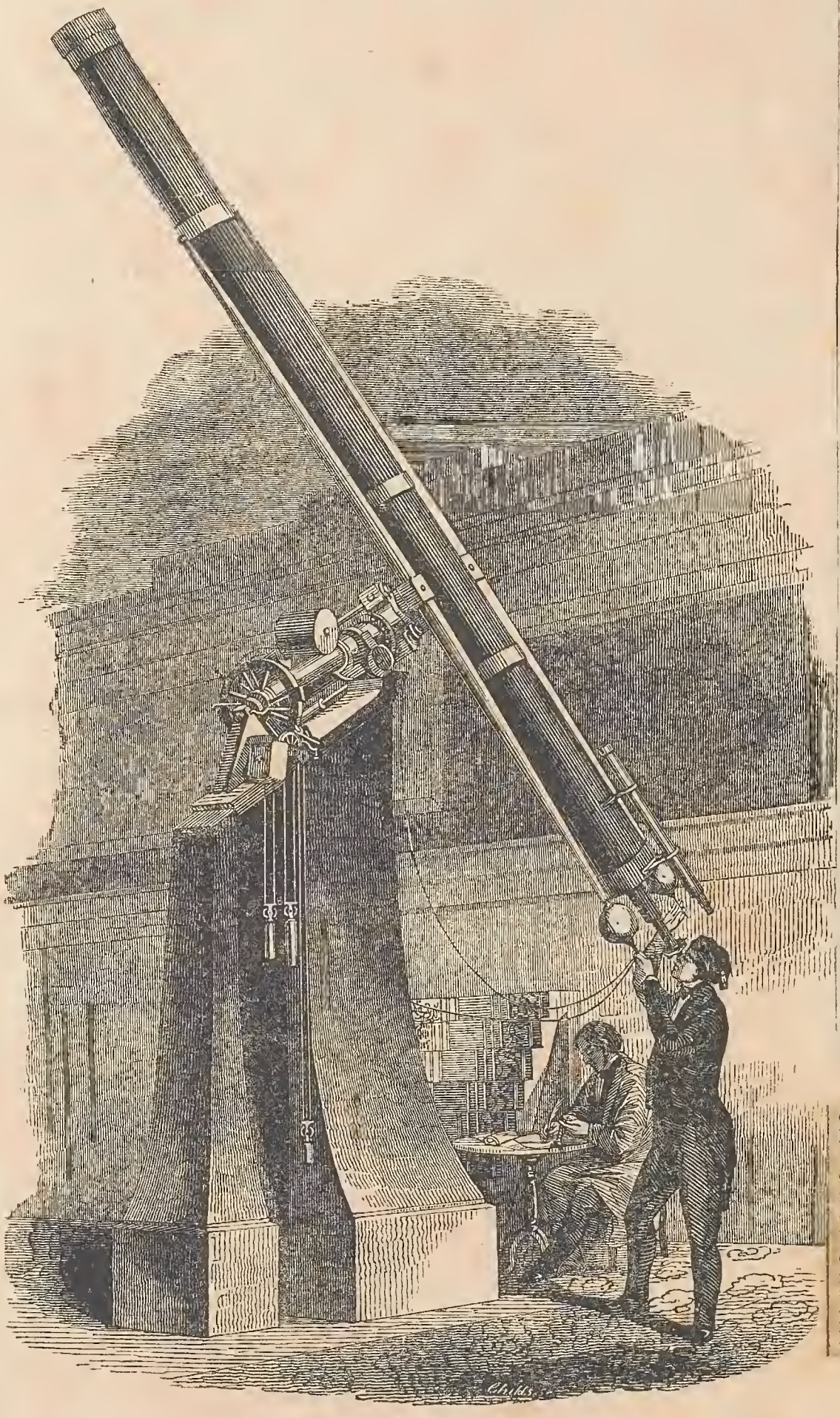
PITIFUL that a man should so care for riches, as if they were his own; yet so use them, as if they were another's; that when he might be happy in spending them, he will be miserable in keeping them; and had rather, dying, leave wealth with his enemies, than, being alive, relieve his friends.

TEN persons will repent for a sin for one who will confess to the person wronged. Yet such confession is in truth far more needful to the wronger than to the wronged. It is a small thing to be wronged, but a horrible thing to wrong.

HE that never changed any of his opinions never corrected any of his mistakes; and he who was never wise enough to find out any mistakes in himself, will not be charitable enough to excuse what he reckons mistakes in others.

MISFORTUNES come to a man through excessive love of self. He misjudges things just, good and beautiful, through thinking he ought always to honor what belongs to himself in preference to truth.

A CERTAIN amount of opposition is a great help to a man. Kites rise against and not with the wind. Even a head wind is better than none. No man ever worked his passage anywhere in a dead calm.



THE LARGEST TELESCOPES IN THE WORLD

Lord Rosse's Telescope, at Birr Castle, Ireland,	56	feet in length.
Sir Wm. Herschel's do. at Greenwich, London,	40	do. in length (not in use)
The Dorpat Telescope, at Dorpat (Russia,) Prof. Struve,	16	"
Sir James South's Telescope at London,	19	"
Cincinnati Telescope, (Ohio,) Prof. Mitchel,	17	"
Telescope at Cambridge, Mass.		

Comet 1, 1881.

Thus far comets have played a small part among the portents of this momentous year. Four months have passed without one trailing wanderer in the celestial depths. That inveterate comet seeker, Professor Swift, succeeded on the first day of May in picking up an infinitesimal member of the family, too small to be seen in anything less than a powerful telescope. No other observer has thus far had a peep at the stranger, and there seems to be little probability of its growth into one of those monstrous prodigies, spanning the heavens, that a few centuries ago were such frightful omens of evil to those who witnessed them. The comet that made its appearance May morning will probably do little harm to our planet. It seems to be a bearer of good fortune, instead of a prophet of disaster, for the discoverer will win a prize of two hundred dollars, as well as a gold medal. Comets must hurry their footsteps to make this comet year. More than one-third of the "great year," 1881, as astrologers call it, has already slipped away, with only one tiny comet recorded on its annals. Prizes of two hundred dollars each are in readiness for seven more comets to be discovered before the year fulfills it course. These astronomical tidbits are, therefore more earnestly desired by comet seekers than they are dreaded by those whose superstitious fears regard them as heralds of destruction. The nineteenth century chronicles the advent of two superb comets, that of 1858, or Donati's comet, and that of 1861. According to the law of averages, we can hardly expect again visits from such distinguished members of the family before the century closes. But we shall see as time passes what the future has in store, for nothing is more uncertain than the advent of these mysterious strangers and one may suddenly beam upon our vision when we least expect it. There are but two things to fear, a great comet plunging headlong into the sun, or one coming into collision with the earth. The probabilities that these events may occur are of the slightest kind, and need not give the least anxiety.

...med the Harvest Moon; but the only true Harvest Moon is that of September. Near the autumnal equinox the plane of the moon's orbit makes so slight an angle with the eastern horizon that her daily advance eastward in her path causes comparatively little difference in the time of her rising. This occurs on both sides of the equinox, and so there are every year two full moons that for several nights together rise at nearly the same time. The second of these, which comes a month later than the Harvest Moon, is called the Hunter's Moon.

HINTS TO TEACHERS.

The author would recommend that whenever a lesson is given to a class, that the teacher call their particular attention to the illustration, and explain, if necessary, the diagrams relating to the lesson given, at the same time questioning the whole class upon the subject; and inviting any pupil who does not fully understand the subject to ask any questions relating to it he may think proper. This will prepare the pupil, when he is studying his lesson, to have a right conception of what he is learning. It is not expected by the author that the teacher will confine himself solely to the questions given in the book; but that he will ask many which may occur to him at that time, and which may lead the pupil off from the routine of the book, and induce him to apply the principles which he is endeavoring to acquire

He would also particularly recommend, that the teacher when hearing a recitation, change the question or put it in a different form, in all cases where it will admit of it. For example:

What is the attraction, by which all particles of matter tend toward each other, called? The attraction of gravitation.

What is the attraction of gravitation? It is that attraction by which all particles of matter tend toward each other.

What is the point in the heavens directly over our heads called? The zenith.

What is the zenith? It is that point in the heavens directly over our heads.

SMITH'S

ILLUSTRATED

ASTRONOMY,

DESIGNED FOR THE USE OF THE

PUBLIC OR COMMON SCHOOLS

IN THE UNITED STATES.

ILLUSTRATED WITH

NUMEROUS ORIGINAL DIAGRAMS.

BY ASA SMITH,
Principal of Public School No. 12, City of New York.

FOURTH EDITION.

NEW-YORK:

PUBLISHED BY CADY & BURGESS,
60 JOHN STREET.
1849.

PREFACE.

It is usual for an author to assign a reason for making a new book. So numerous are the works on Astronomy, that some will think another not needed. It is true that many learned and able men have presented to the schools, works on Astronomy. Some are written in an elevated style, presupposing in the reader a good degree of scholarship, and acquaintance with the higher mathematics, not to be found in common schools. Others have written treatises of merit, but have failed to illustrate them in such a manner as to make them easily understood by common readers: and others again have extensive illustrations, on so magnificent and costly a plan that they cannot be afforded to each scholar of a class in a common school.

It has been the object of the author of this little manual of Astronomical science, to present all the distinguishing principles in physical Astronomy with as few words as possible; but with such occular demonstrations, by way of diagrams and maps, as shall make the subject easily understood. The letter press descriptions and the diagramatic illustrations will invariably be found at the same opening of the book; and more explanatory cuts are given, and at a much less price than have been given in any other elementary Astronomy.

The work is designed for common schools, but may be used with advantage as an introductory work in high-schools and academies. In the preparation of these pages most of the best works in our language have been consulted, and the best standard authorities, with regard to new discoveries and facts, have governed the writer's decisions.

The Diagrams, which are larger and more full than those of any other work adapted to common schools, are many of them original in their design, and exhibit the positions and phases of the planets in their orbits. The drawings being upon the principle of perspective, exhibit the inclinations of their several axes to the planes of their orbits more correctly than has hitherto been done in any other popular work. It is well to intimate to the young elementary student, who has made himself somewhat acquainted with the sublime mechanism of the solar system, that there is something more magnificent beyond. Accordingly the author has given a few Sidereal Maps, just to awaken in the young astronomer the amazing conception, that unnumbered suns and revolving worlds occupy the depths of space far beyond the confines of our planetary system. By these maps he will be able to learn the relative positions of the principal constellations and stars, which will be found useful and interesting to him in subsequent investigations of the ennobling truths of mathematical Astronomy.

The writer is not so vain as to suppose that he has been able to present to teachers a faultless work; but in his own practice, finding it tedious and often difficult to explain all the representable phenomena of the science on the *black-board*, and finding also a general concurrence of opinion among teachers most interested in the study of Astronomy, that a cheap, compact, and illustrated work is necessary in our common schools, he has attempted the production of such a work. With what success, and with what favor it will be received by his co-laborers, remains to be seen; but whether it meet the kind greetings of those whose good opinion is most desired, or not, the author has this to console him, that his long continued labors in preparing the illustrations of the work, were not only well intended, but have already been productive of useful results to himself and to the pupils of his own school.

Objections which are sometimes urged against questions and answers, in an elementary work, will not, the Author hopes, be urged in this case, as the pupil has the subject, fully illustrated, continually before the eye, while he is learning his lesson.

To the Teachers, of our common country, this work is most respectfully dedicated, in the sincere desire that the cause of education may be benefitted, and the labors of instruction in Astronomy may be rendered more easy and pleasant, from the illustrations it contains. As an apology to my fellow Teachers in the city of New-York, for the long delay in the publication of this work, (they being aware that the author had such a work in progress,) he deems it sufficient to state that it has occupied the whole of his spare time for nearly three years; the most laborious part of it being the drawing of the diagrams, &c. on wood, ready for the *tool* of the *engraver*, which was done by the Author himself. In putting the work in type, it was found that there was not sufficient room on the opposite page, in many cases, for all the notes and explanations which the Author had prepared, and which were more particularly designed for the benefit of Teachers. These notes and explanations will be added to the next edition in an *appendix;* besides some other matter, which, for the want of time, has been left out of this edition. Such additions will be made to the work in subsequent editions as shall appear desirable. The author would take this occasion to acknowledge with gratitude the voluntary assistance rendered him by his particular friend James H. Partridge, Esq., Principal of Ward School No. 18, in revising portions of the text, correcting proofs, &c.

ASA SMITH, Principal of Public School No. 12,
Seventeenth Street, near Eighth Avenue, City of New York.

NAMES AND CHARACTERS OF THE SIGNS, PLANETS, AND ASPECTS.

Aries, - - - - ♈	Sagittarius, - - - ♐	Earth, - - - - ⊕	Hebe,* - - - - -	Quartile, - - - □
Taurus, - - - - ♉	Capricornus, - - ♑	Mars, - - - - ♂	Iris,* - - - - - -	Trine, - - - - △
Gemini, - - - - ♊	Aquarius, - - - ♒	Vesta, - - - - ⚶	Jupiter, - - - - ♃	Opposition, - - - ☍
Cancer, - - - - ♋	Pisces, - - - - ♓	Juno, - - - - - ⚵	Saturn, - - - - ♄	Ascending Node, - ☊
Leo, - - - - - ♌	Sun, - - - ☉ or ⊙	Ceres, - - - - ⚳	Herschel, - - - ♅	Descending Node, ☋
Virgo, - - - - ♍	Moon, - ● ○ ◍ ◍	Pallas, - - - - ⚴	Leverrier, - - - ♆	.....
Libra, - - - - ♎	Mercury, - - - ☿	Astræa,* - - - -	Conjunction, - - ☌	.....
Scorpio, - - - - ♏	Venus, - - - - ♀	Flora,* - - - -	Sextile, - - - - *	.....

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Cancer, ♋	Pisces, ♓	Juno, ⚵	Saturn, ♄	Ascending Node, ☊
Leo, ♌	Sun, ⊙ or ☉	Ceres, ⚳	Herschel, ♅	Descending Node, ☋
Virgo, ♍	Moon, ● ○ ◐ ◑	Pallas, ⚴	Leverrier, Ψ	.....
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Scorpio, ♏	Venus, ♀	Flora,*	Sextile, *	.....

* Not determined.


LEVERRIER
JUNO
VESTA
PALLAS
CERES
MARS
EARTH
JUPITER
ASTRÆA
MERCURY
VENUS
COMET
SATURN
HERSCHEL
JUNE
JULY
AUG
SEP
OCT
NOV

INTRODUCTION TO ASTRONOMY.

LESSON I.

Question. WHAT is the body called upon which we live?
Answer. It is called the EARTH, or WORLD.

Q. What idea had the ANCIENTS respecting the shape of the earth?
A. They believed it was an extensive plain, rendered uneven by hills and mountains.

Q. Why did they think it was an extended plain?
A. Because they formed their opinions from appearances only.

Q. Did they believe that the earth had any motion?
A. They did not; they believed that the earth rested on a solid, immovable foundation.

[They very naturally came to this conclusion, as they were entirely ignorant of the laws of attraction or gravitation. They believed that if the earth were to turn over, that every thing would be precipitated from its surface.]

Q. Had they any definite ideas respecting what held the earth up?
A. Their views were very vague and unsatisfactory.

[There have been many absurd ideas advanced, at different ages of the world, as to what supported the earth. Some supposed it to be shaped like a CANOE, and to float upon the waters; others, that it rested upon the back of an ELEPHANT, or huge TURTLE; while, according to mythology, Atlas supported it upon his shoulders: but, what kept the waters in their place, or upon what the Elephant, Turtle, or Atlas stood—this was a mystery they COULD NEVER SOLVE.]

Q. Did they believe the earth extended the same distance in all directions?
A. They believed it to extend much farther from east to west than from north to south.

[They observed that in going east or west, on the same parallel of latitude, no change took place in the appearance of the heavens; but in going north or south, on the same meridian, every sixty miles caused a difference of one degree in the elevation of the pole, and in the position of the circles of daily motion of the sun and other heavenly bodies; therefore they concluded that the earth was very long from east to west, but comparatively narrow from north to south. From this originated the use of the TERMS longitude and latitude; longitude meaning length, and latitude, breadth.]

Q. What ideas had they respecting the motions of the sun, moon, and Stars?
A. They supposed that they revolved around the earth, from east to west, every day.

Q. What was this system called, that supposed the earth to be at rest in the centre, and all the heavenly bodies to revolve around it?
A. The Ptolemaic system.

[Ptolemy asserted, that the sun, moon, planets, and stars revolved around the earth, from east to west, every 24 hours; and to account for their not falling upon the earth, when they passed over it, he supposed that they were each fixed in a separate, hollow crystalline globe, one within the other. Thus the moon was in the first; Mercury in the second; Venus in the third; the sun in the fourth; Mars in the fifth; Jupiter in the sixth; Saturn in the seventh;—(the planet Herschel was not known at this time)—the fixed stars in the eighth. He supposed the stars to be in one sphere as they are kept in the same positions with respect to each other. To permit the light of the stars to pass down to the earth, he supposed these spheres or globes were perfectly clear or transparent like glass. The power which moved these spheres, he supposed, was communicated from above the sphere which contained the stars.]

LESSON II.

Question. EVERY one is conscious that the sun, which rises daily in the east and sets in the west, is the same body; where does it go during the night?
Answer. It appears to pass round under the earth.

Q. When we look out upon the stars, on successive evenings, they appear to have a definite position with respect to each other, and a westward movement like the sun; what motion do they appear to have from their setting to their rising?
A. They appear to pass under the earth.

Q. From the north to the south point of the heavens, there is a continuous arc of stars, and in their passage under the earth they are not at all disarranged, what can you infer from this fact?
A. That they pass completely around the earth, and every thing attached to it.

Q. We see no body at rest that does not touch some permanent support, but we see bodies in motion supported for different lengths of time without resting upon any other surface; if the earth is hung upon nothing, is it probably at rest?
A. It is more probable that it is in motion.

Q. If we throw a ball, does the same side always remain forward?
A. It does not; it turns over continuously.

Q. What do we call the line round which it turns?
A. Its axis.

Q. If a fly were on the ball, would distant objects appear to him to be stationary?
A. They would appear to revolve around the ball, as often as it turned over.

Q. If the earth is moving in space, is it in accordance with the known motion of ordinary bodies, to suppose that the same side remains forward?
A. It is not. It is more reasonable to suppose that it turns on its axis.

Q. If the earth turns, and we are carried round on its surface, what appearance must the sun and distant stars necessarily present?
A. They must appear to move around the earth in the opposite direction.

LESSON III.

Question. WHAT other reason can you give for the earth's turning?
Answer. The stars are so distant, that their motion would be immensely swift, in comparison with the motion of the earth, to produce the same effect.

Q. But have we not positive proof, and that too of different kinds, that the earth turns on its axis?
A. We have.—1. The shape of the earth, elevated at the equator and depressed at the poles, can be accounted for on no other supposition.

2. A body at the equator, dropped from a great height, falls eastward of the perpendicular.

3. The trade winds and ocean currents in the tropical regions are clearly traceable to the same cause.

Q. If the earth is moving in space, does it proceed in a straight line?
A. It does not; but it would do so, were it not attracted by other bodies.

Q. What is the attraction, by which all particles of matter tend towards each other, called?
A. The attraction of gravitation.

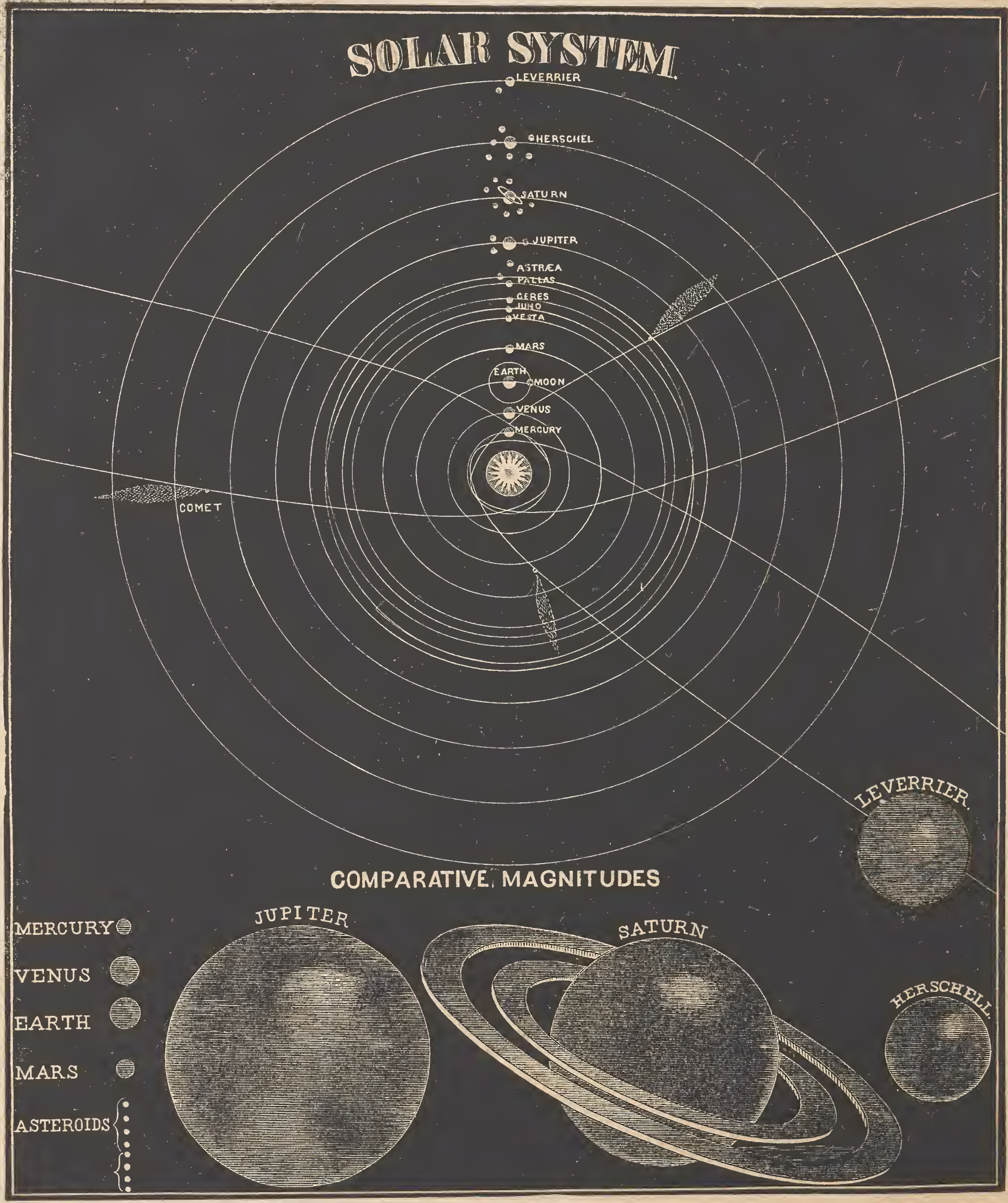
Q. What large body, by its attraction, causes the earth to revolve around it in a curve line?
A. The sun.

Q. What other similar bodies revolve around the sun?
A. The planets.

Q. What may we call the earth, when considered with regard to its size, shape, motions, &c.?
A. One of the planets.

Q. What science describes these characteristics of the earth, and other heavenly bodies?
A. Astronomy.

SOLAR SYSTEM.



COMPARATIVE MAGNITUDES

LESSON IV.

ASTRONOMY.

Question. What is astronomy?

Answer. Astronomy is the science which treats of the heavenly bodies.

Q. What are the heavenly bodies?

A. The sun, moon, planets, comets, and stars,

Q. What are some of their characteristics, of which astronomy treats?

A. Their appearance, size, shape, arrangement, distance, motions, physical constitution, mutual influence on each other, &c.

Q. Are they all of the same magnitude, or size?

A. The sun and stars are much larger than the other bodies.

Q. Are they all at the same distance from the earth?

A. They are not; the moon is the nearest, and the stars the most distant.

Q. Do they all emit light of themselves?

A. They do not.

Q. How are they divided in this respect?

A. They are divided into two classes, luminous and opake.

Q. What is a luminous body?

A. It is a body which shines by its own light.

Q. What is an opake body?

A. It is a body which shines only by reflecting the light of a luminous body.

Q. Which are the luminous bodies in the heavens?

A. The sun and fixed stars are luminous bodies.

Q. Which are the opake bodies in the heavens?

A. The moon, planets, and comets.

Q. Why do the moon, planets, and comets appear luminous?

A. Because they reflect to us the light of the sun.

Q. What is the shape of the heavenly bodies?

A. They are round like a globe or ball.

Q. What do the sun, moon, planets, and comets constitute?

A. They constitute the solar system.

LESSON V.

THE SOLAR SYSTEM.

Question. How are the bodies constituting the solar system arranged?

Answer. The sun is placed in the centre of the system, with the planets and comets revolving around it at unequal distances.

Q. How many planets are there in the solar system?

A. Thirty-five is the number known at present.

Q. How are they divided with respect to their motion?

A. They are divided into two classes, primary and secondary.

Q. What is a primary planet?

A. It is a planet which revolves around the sun only.

Q. What is a secondary planet?

A. It is a planet which revolves around its primary, and with it around the sun.

Q. What are the secondary planets usually called?

A. They are called satellites or moons.

Q. How many primary planets are there?

A. Sixteen; eight being asteroids or small planets.

Q. What are their names, beginning at the sun?

A. Mercury, Venus, the Earth, Mars, (Vesta, Astræa. Juno, Ceres, Pallas, Hebe, Iris, Flora,) Jupiter, Saturn, Herschel, or Uranus, and Leverrier, or Neptune.

Q. How many secondary planets or moons are there?

A. Nineteen.

Q. Which planets have moons?

A. The Earth has one, Jupiter 4, Saturn 7, Herschel 6, and Leverrier 1.

LESSON VI.

Question. How many revolutions has a primary planet?

Answer. Two; one on its axis, and another around the sun.

Q. What is the axis of a planet?

A. It is a straight line, round which it turns.

Q. What is the path called, in which a planet revolves around the sun?

A. It is called its orbit.

Q. What is the earth's orbit called?

A. It is called the ecliptic.

Q. Why is it so called?

A. Because eclipses take place, only when the moon is in its plane.

Q. How many revolutions has a secondary planet?

A. Three. 1st, the revolution upon its axis; 2d, the revolution around its primary; 3d, the revolution with its primary around the sun.

Q. How are the planets divided, with respect to their distance from the sun?

A. Into inferior and superior, according as their distance from the sun is inferior or superior to that of the earth.

Q. Which are the inferior planets?

A. Mercury and Venus.

Q. Which are the superior?

A. Mars, the Asteroids, Jupiter, Saturn, Herschel, and Leverrier.

LESSON VII.

DIAMETERS.		MAGNITUDES; THE EARTH BEING 1.	DISTANCES FROM THE SUN.	REVOLUTION ON THEIR AXIS.		REVOLUTION AROUND THE SUN.	
	Miles.		Miles.	Days.	Hours	Years.	Days.
Sun,	886,952	1,384,472		25	10		
Mercury,	3,200	..... $\frac{1}{17}$	37,000,000		24		88
Venus,	7,700	..... $\frac{9}{10}$	68,000,000		23½		224
Earth,	7,912	 1	95,000,000		24	1	0
Mars,	4,189	..... $\frac{1}{7}$	142,000,000		24½	1	321
Vesta,	270	... $\frac{1}{21000}$	225,000,000	Unknown.		3	230
Astræa,	unknown.	Unknown.	253 000,000	"		4	105
Juno,	1,400	..... $\frac{1}{186}$	254,000,000	"		4	131
Ceres,	1,600	..... $\frac{1}{135}$	263 000,000	"		4	222
Pallas,*	2,100	..... $\frac{1}{55}$	263,000,000	"			
Hebe,	unknown.	Unknown.	Unknown.	"			
Iris,	"	"	"	"			
Flora,	"	"	"	"			
Jupiter,	87,000	1,280	485,000,000		10	11	314
Saturn,	79,000	1,000	890,000,000		10½	29	167
Herschel,	35,000	80	1,800,000,000			84	5
Leverrier,	35,000	80	2,850,000,000			166	

* Herschel estimated the diameter of each of the asteroids to be under 200 miles. Their great distance, extreme smallness, and nebulous appearance, render it extremely difficult to ascertain their size with accuracy.

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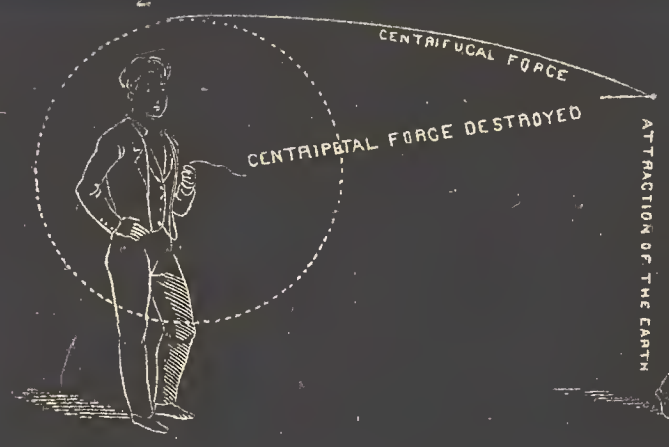

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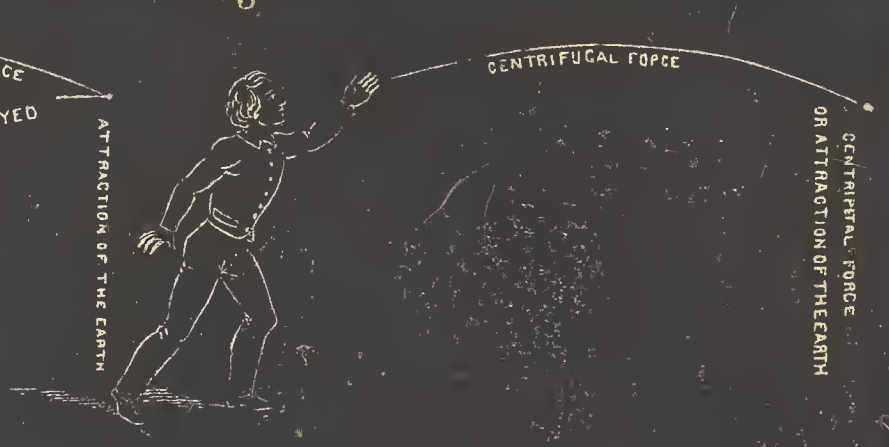

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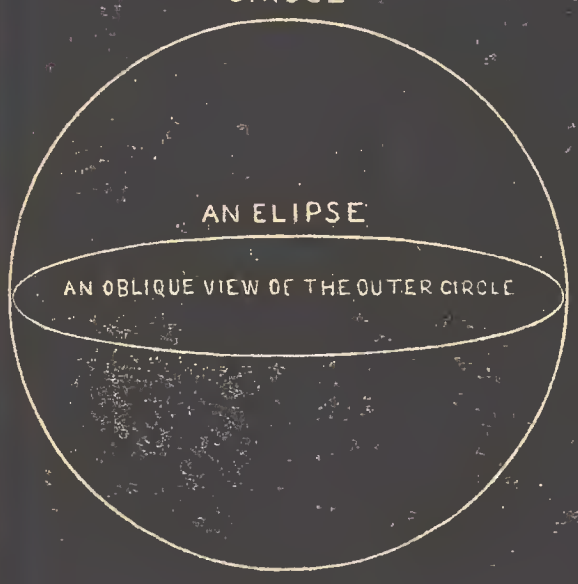
CIRCLE



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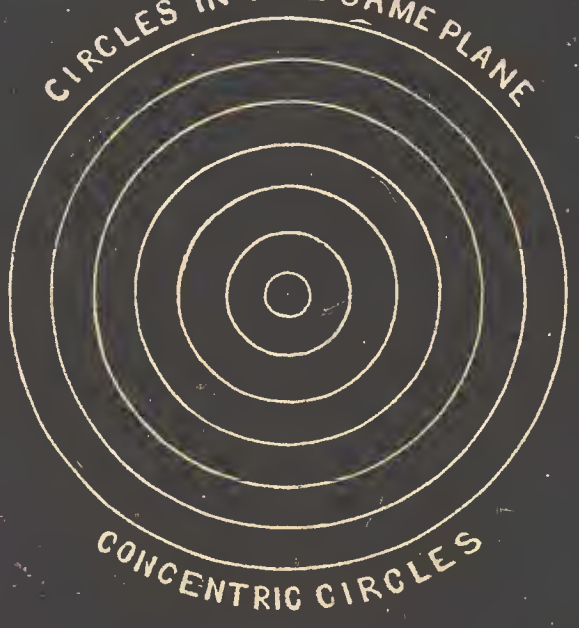

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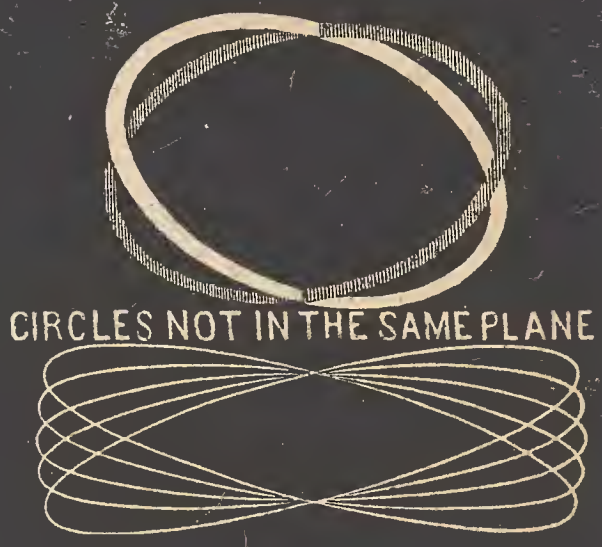


7

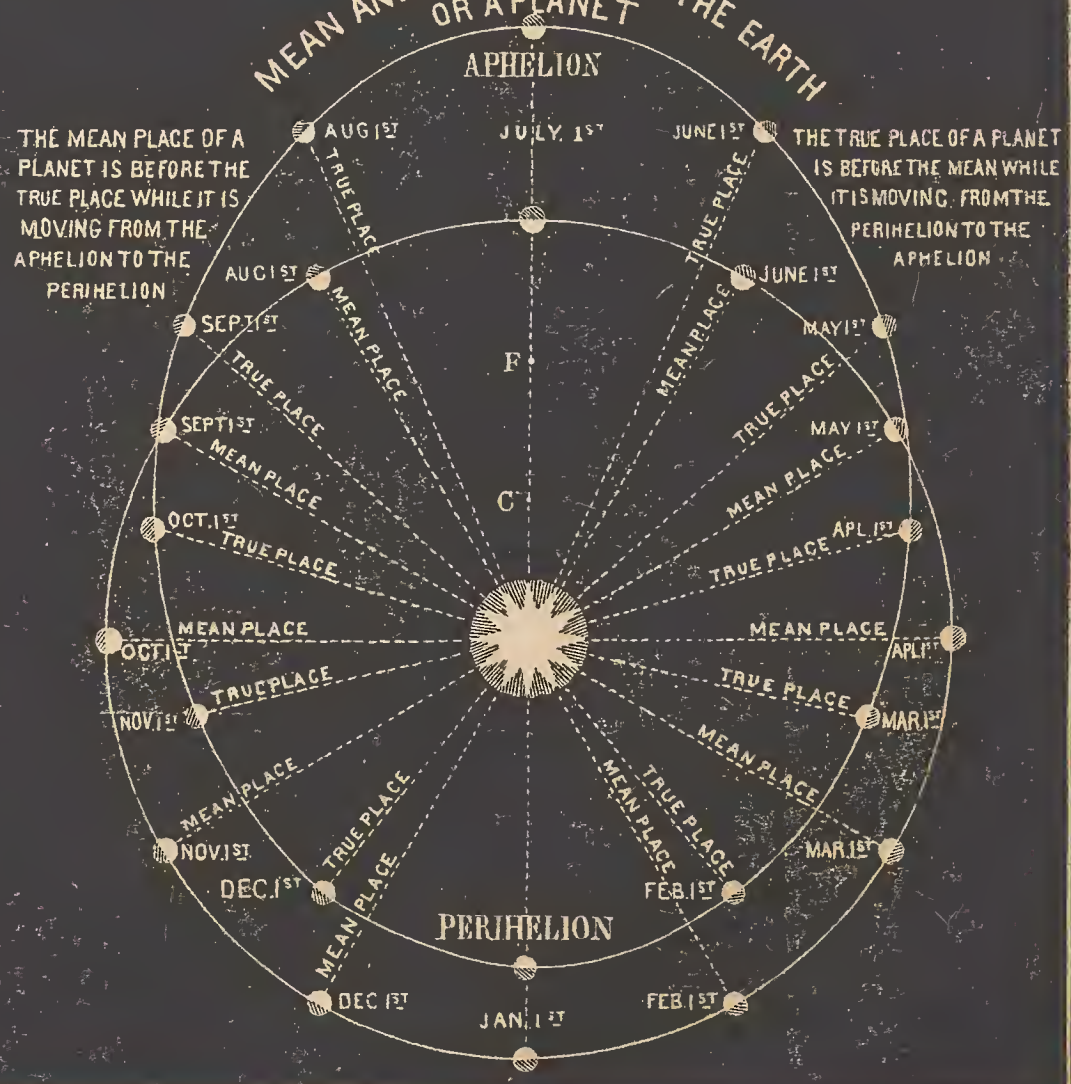
KEPLER'S LAWS

8

MEAN AND TRUE PLACE OF THE EARTH OR A PLANET

THE MEAN PLACE OF A PLANET IS BEFORE THE TRUE PLACE WHILE IT IS MOVING FROM THE APHELION TO THE PERIHELION

THE TRUE PLACE OF A PLANET IS BEFORE THE MEAN WHILE IT IS MOVING FROM THE PERIHELION TO THE APHELION



LESSON VIII.

CENTRIPETAL AND CENTRIFUGAL FORCE.

Question. WHAT is that force called with which all bodies attract each other in proportion to their mass?

Answer. The attraction of gravitation.

Q. What is centripetal force?

A. It is the force which draws a body towards the centre round which it is revolving.

Q. What large body by its attraction exerts a centripetal force upon all the primary planets and comets?

A. The sun.

Q. What body exerts a centripetal force upon the moon?

A. The earth.

Q. What bodies exert a centripetal force upon the other moons?

A. The primary planets around which they revolve.

Q. What is the centrifugal force of a heavenly body?

A. It is that force which moves it forward in its orbit.

Q. How do these two forces cause the planets to move?

A. They cause them to move in circular or elliptical orbits.

Q. What is a circle?

A. It is a plane figure bounded by a curve line, all parts of which are equally distant from the centre.—(FIG. 4.)

Q. What is an ellipse?

A. It is an oblique view of a circle. (FIG. 4.)

[NOTE.—Teachers should be sure that the pupils understand the definition of an ellipse, because in viewing some of the diagrams they may receive a wrong impression. In the diagram representing the seasons, the earth's orbit appears very elliptical: this would be well understood by the pupil, should the teacher call his particular attention to it. Also, a plane of a circle should be well understood.]

Q. What are the foci of an ellipse?

A. They are the two points around which the ellipse is drawn. (FIG. 7.)

Q. Where are these points situated?

A. In the greater axis, at equal distances from the centre.

Q. What is the eccentricity of an ellipse?

A. It is the distance from the centre to either of the foci. (FIG. 7.)

Q. Where is the sun situated within the orbit of each planet?

A. It is situated in one of the foci. (FIG. 8.)

Q. When are circles in the same plane? (FIG. 5.)

A. When their planes lie in the same straight line.

Q. When are circles not in the same or parallel planes?

A. When their planes intersect each other. (FIG. 6.)

LESSON IX.

Question. How many laws did Kepler discover, which bear his name?

Answer. Three.

Q. To what do they relate?

A. They relate to the motions of the planets.

Q. What is the first law of Kepler?

A. That all the planets revolve in elliptical orbits, having the sun in one of their foci. (FIG. 7.)

Q. What is the second law?

A. That the radius vector passes over equal spaces in equal portions of time.

Q. What is the radius vector?

A. It is a line drawn from the sun to a planet, in any part of its orbit. (FIG. 7.)

Q. What is the third law?

A. It is that the squares of the times of the revolutions of the planets around the sun, are proportional to the cubes of their mean distances from the sun.

THE MEAN AND TRUE PLACE OF A PLANET.

Q. What is the mean place of the earth, or a planet in its orbit?

A. It is that point in its orbit where it would be if it moved in a circle, and with the same velocity at all times. (FIG. 8.)

Q. What is the true place of the earth or a planet?

A. It is that point in its orbit where it really is at any given time. (FIG. 8.)

Q. What is the aphelion?

A. It is that point in the orbit of the earth or planet farthest from the sun. (FIG. 8.)

Q. When is the earth in the aphelion, or farthest from the sun?

A. July 1st. (FIG. 8.)

Q. What is the perihelion?

A. It is that point in the orbit of the earth or planet nearest to the sun. (FIG. 8.)

Q. When is the earth in the perihelion, or nearest to the sun?

A. January 1st. (FIG. 8.)

LESSON X.

Question. IN what points of a planet's orbit do its mean and true places coincide?

Answer. At the aphelion and perihelion. (SEE FIG. 8.)

Q. What straight line connects these points, and passes through the sun?

A. The apsis line.

Q. When is the true place of the earth or planet behind its mean place?

A. While it is moving from the aphelion to the perihelion. (SEE FIG. 8.)

Q. When is the true place of the earth or planet before its mean place?

A. While it is moving from the perihelion to the aphelion? (SEE FIG. 8.)

Q. When does it move with the least velocity?

A. When it is at its greatest distance from the sun.

Q. When is the motion of the earth or planet in its orbit increasing?

A. When it is moving from the aphelion to the perihelion.

Q. Why does the motion increase from the aphelion to the perihelion?

A. Because it is approaching nearer to the sun.

Q. What causes it to approach the sun?

A. The centrifugal force at the aphelion is not sufficiently great to prevent it falling towards the sun.

Q. When does the earth or planet move with the greatest velocity?

A. When it is the nearest to the sun.

Q. When is the motion of the earth or planet decreasing?

A. While it is moving from the perihelion to the aphelion.

Q. Why does the motion decrease from the perihelion to the aphelion?

A. Because the planet is receding from the sun.

Q. What causes it to recede from the sun?

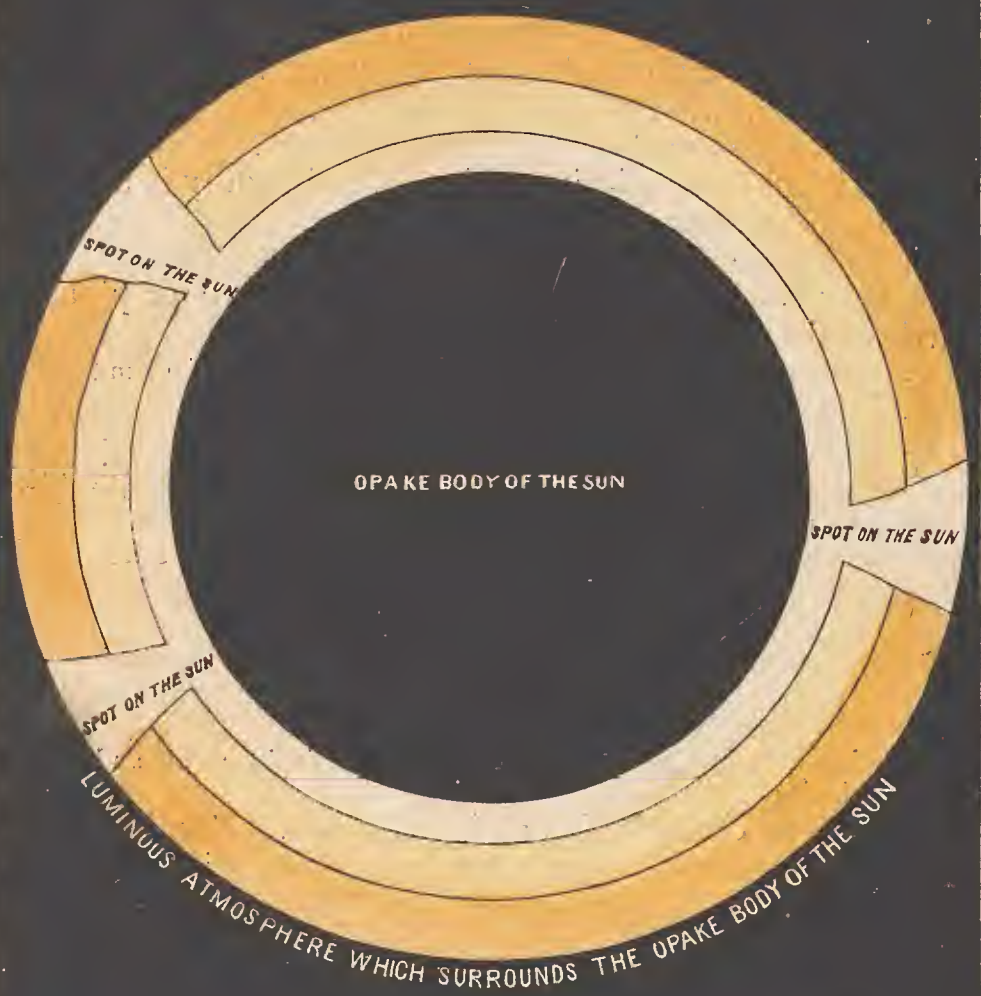
A. The centrifugal force at the perihelion is so great as to carry it farther from the sun.

CENTRIPETAL AND CENTRIFUGAL FORCES.

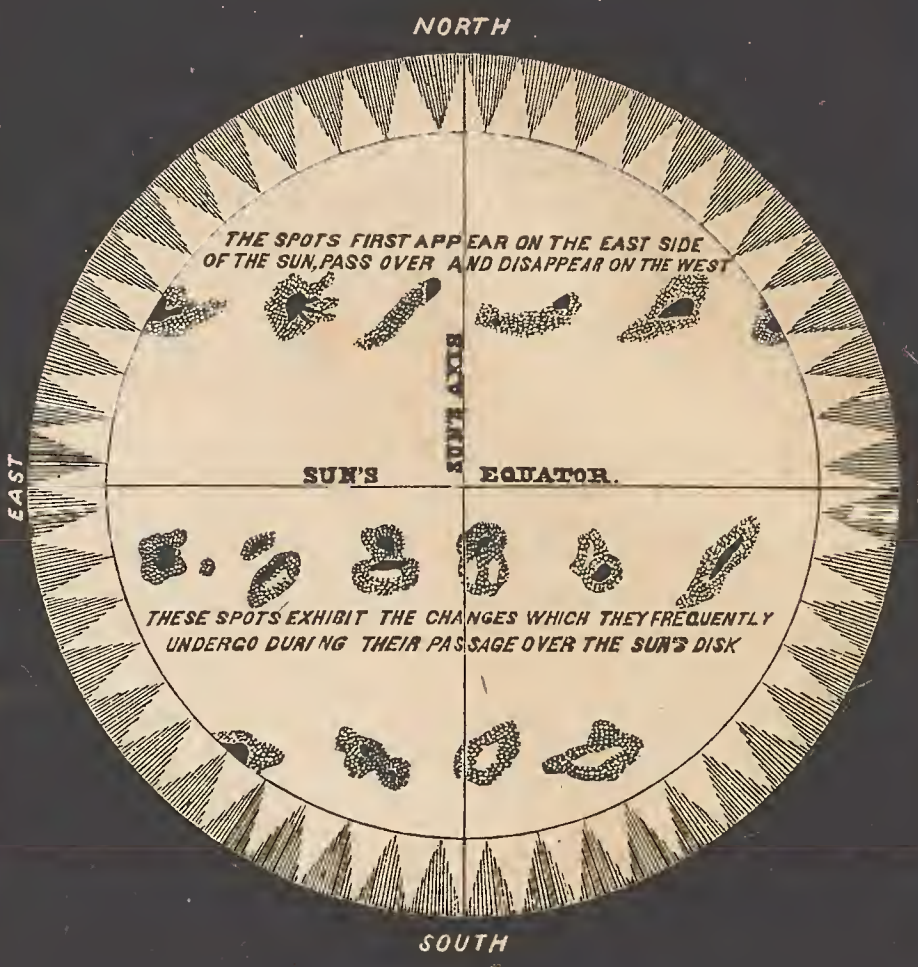
A body projected by any force would always move forward in a straight line, and with the same velocity, unless acted upon by some other force. A ball discharged from a gun or thrown from the hand soon looses its projectile force by the resistance of the atmosphere, and is brought to the ground by the attraction of the earth, or centripetal force. (FIG 3) These two forces can be well illustrated, (SEE FIG. 1, 2,) by tying a string to a ball and swinging it round; the centrifugal force imparted to the ball by the hand and by means of the string, causes the ball to move in a circle; but if the string should break, the centrifugal force would carry it off in a straight line, if the ball were not attracted by the earth. The string corresponds to the attraction of the sun in our solar system, which causes the planets to move in regular curves around the sun, instead of straight line. If the attraction of the sun or centripetal force should cease, the planets would fly off into space in straight lines; but if the centrifugal force should cease and the centripetal force continue, the planets would immediately fall into the sun.

A CUT SECTION OF THE SUN

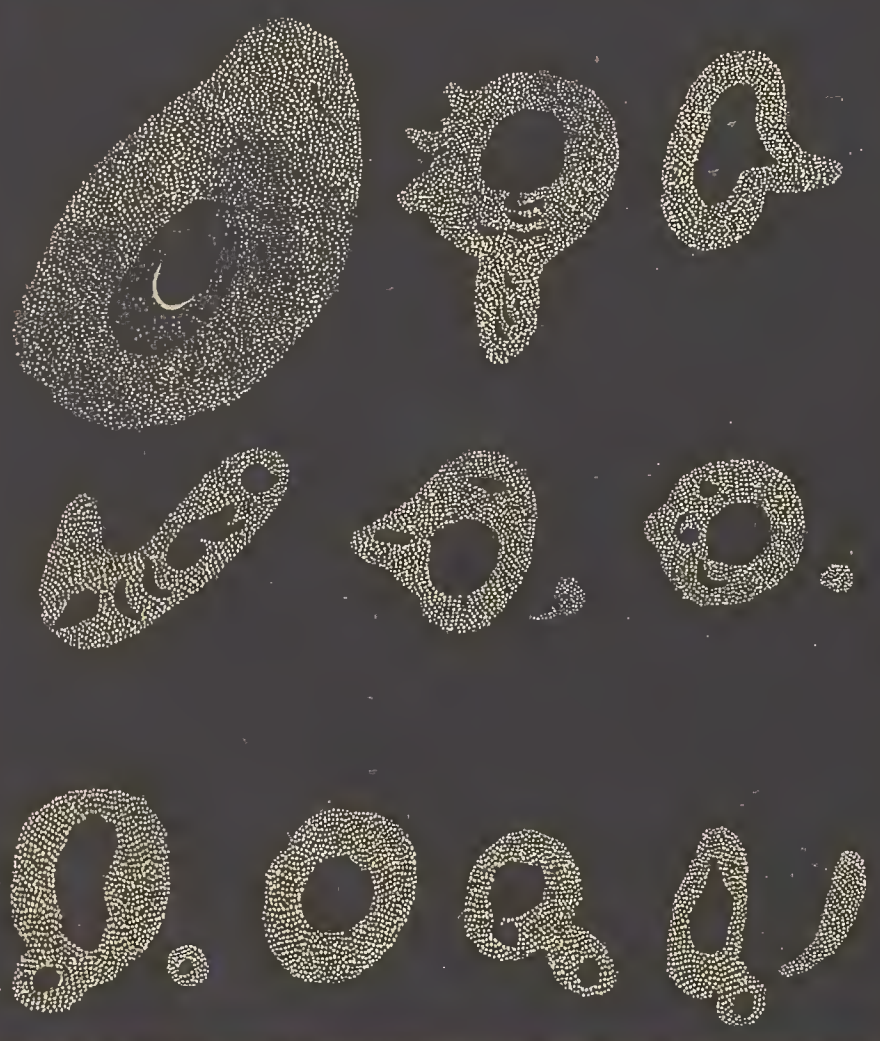
SHOWING THE SPOTS, THE LUMINOUS ATMOSPHERE, AND THE OPAKE BODY OF THE SUN.



SPOTS ON THE SUN.



REMARKABLE SPOTS THAT HAVE BEEN DISCOVERED UPON THE SUN



TRANSITS OF MERCURY & VENUS UNTIL THE YEAR 1900

LESSON XI.

THE SUN.

Question. What body is in the centre of the solar system?

Answer. The sun.

Q. Describe the sun?

A. The sun is a large luminous body, which gives light and heat to the whole solar system.

Q. What is the diameter of the sun?

A. 886,952 miles.

Q. How much larger is the sun than the earth?

A. It is 1,384,472 times greater.

Q. What is the specific gravity of the sun?

A. It is 1⅓ the weight of water. (1.38.)

Q. What is the size of the sun compared with the planets?

A. It is 500 times as great as the bulk of all the planets.

Q. What can you say of its mass or weight?

A. It is about 750 times the mass of all the planets.

Q. What is the distance of the sun from the earth?

A. It is about 95,000,000 of miles.

Q. What did the ancient astronomers consider the sun to be?

A. A large globe of fire.

Q. What do astronomers at the present day consider it to be?

A. An opake body like the earth, surrounded by a luminous atmosphere.

Q. What motions has the sun?

A. It has three motions—1st, on its axis; 2d, around the centre of gravity of the solar system; 3d, around the centre of the universe.

[The term universe is used by astronomers, though perhaps improperly, to designate the great cluster or firmament of stars in which our sun is situated.—(See pages 45 and 46) This cluster includes all the single stars that can be seen with the naked eye, and all those composing the galaxy or milky way. The number of stars or suns in the cluster is estimated at many millions; all which, like our sun, are supposed to revolve around the common centre of gravity of the whole cluster. Several thousand other distinct clusters or nebulæ, situated without our firmament, can be seen by the best telescopes, nearly all of which are invisible to the unassisted eye.]

LESSON XII.

Question. What is the inclination of the sun's axis to that of the ecliptic?

Answer. About 7⅓ degrees.

Q. In what time does it revolve on its axis?

A. In about 25 days and a half.

Q. How is the revolution of the sun on its axis determined?

A. By spots on its surface, which first appear on the east side, pass over, and disappear on the west side.

Q. What is the nature of these spots?

A. They are supposed to be openings in the luminous atmosphere, which enable us to see the dark body of the sun.

Q. What occasions these openings in the luminous atmosphere?

A. They have been attributed to storms and various other causes.

Q. Do these spots undergo any changes?

A. They are constantly changing, and sometimes very rapidly. Some have appeared, others disappeared suddenly.

Q. On what part of the sun do they appear?

A. Within about thirty degrees of the equator.

Q. Is the surface of the sun, in the region of the spots, tranquil or agitated?

A. It is in a state of continual and violent agitation.

Q. What reasons have we to suppose that the luminous part of the sun is intensely hot?

A. 1st, the heat of its rays, when collected into a focus, is very great. 2d, its rays pass through glass with the greatest facility, (a property belonging to artificial heat in direct proportion to its intensity.) 3d, the brightness of the sun is greater than the most vivid flames, or the most intensely ignited solids.

LESSON XIII.

TRANSIT OF MERCURY AND VENUS.

Question. What is the transit of a heavenly body?

Answer. It is its passage across the meridian.

Q. What is generally meant by the transit of Mercury and Venus?

A. It is their passage across the sun's disc.

Q. What is the disc of the sun or a planet?

A. It is the circular illuminated surface visible to us.

Q. How do Mercury and Venus appear, when passing across the sun's disc?

A. They appear like black spots moving across the sun.

Q. What proof have we that Mercury and Venus are not luminous bodies?

A. When viewed with the telescope they appear horned like the moon.

Q. On which side of the sun does a transit begin?

A. On the east side, and terminates on the west side.

THE SPOTS ON THE SUN.

Astronomers do not agree, in all respects, as to the cause of the spots on the sun. From the facts already known, the following appears to be the most rational view of the subject. The body of the sun, which is opake, is surrounded by a transparent atmosphere, in which float two strata of luminous clouds; the lower stratum being more dense and opake, and less luminous than the upper; while the latter, by its brilliancy, furnishes the greater portion of the intense light of the sun. Above the upper stratum, the transparent atmosphere extends to a great height. The agency by which the light and heat of the sun are generated, is not known. The only agent of which we know, that presents analogous phenomena, is electricity. The northern lights are supposed to exhibit, in a feeble manner, an action similar to the luminous strata of the sun. The polar regions of the sun are tranquil, and the equatorial comparatively so; but the surface on each side of the equator, from 15 to 25 degrees therefrom, is in a state of constant and violent agitation. It is in this disturbed region that the spots are seen; no spot ever occurring farther than about 30 degrees from the equator. The spots, besides revolving with the sun, are found to have a motion from the equator towards the poles, and when they arrive at the comparatively calm region, they gradually disappear. Sometimes they close up with great rapidity, at others they appear to be suddenly broken into fragments and dispersed. Bright spots and streaks, called faculæ, apparently caused by waves in the luminous portion of the atmosphere, also appear on various parts of the disc, but are seen most distinctly near the margin. In the places where spots appear, faculæ are usually seen on the day previous to their breaking out.

But what causes the agitation of the sun's atmosphere, which is so great as frequently to burst open the luminous strata? Astronomers, at different times, have suggested various causes for the sun's spots, such as jets of gas issuing from the sun and decomposing the luminous clouds; high mountains, extending through the luminous strata; volcanoes, sending forth ashes, smoke, &c.; to say nothing of exploded theories of an older date, such as ashes, scoriæ, &c., on the surface of the melted, burning mass; or bodies very near the sun, revolving round it. But if we are permitted to reason from what takes place on the earth, we would say, that a close analogy exists between the phenomena observed in our own atmosphere and in that of the sun. On the earth the heat of the torrid zone causes the air to expand and rise, causing currents in the lower part of the atmosphere towards the equator, and in the upper part of the atmosphere currents towards the poles. The turning of the earth on its axis causes the under currents to take a westerly direction, while the upper currents sweep in a curve, westerly first, then towards the poles, and finally eastward. The principal disturbance of the atmosphere caused by the trade wind is in the vicinity of the tropics. Storms commencing in the torrid zone, are carried in the direction of the upper currents of air. For instance, a storm started in the West Indies, by the heating of the air over one of its islands, thus causing an upward and circular movement of the air, usually sweeps to the west and north over Florida, or the Gulf of Mexico, and then northeast, over the United States. Similar causes acting upon the atmosphere of the sun, would exhibit phenomena similar to those which we see. This explanation supposes the atmosphere of the sun to be warmer at the equator than at the poles; but as the sun does not, like the earth, receive its heat from any extraneous body, its difference of temperature must be sought for in the escape of its heat. It could attain this condition either by a more free radiation of heat at the poles than at the equator, or by its absorption as latent heat, in the evaporation from large bodies of water in the polar regions. As the sun turns on its axis, its equatorial diameter must be greater than its polar, and the stratum of atmosphere above the luminous clouds must be thicker over the equatorial region than over the polar. This must render the radiation less free at the equator than at the poles, and cause that part of the sun to be of a higher temperature. An excess of heat at the sun's equator, with its rotation on its axis, is sufficient to cause currents in its atmosphere similar to our trade winds, and thus disturb its equatorial regions; and if the spots are caused by storms bursting open the luminous strata, their receding from the equator towards the poles is undoubtedly the effect of the same physical causes that give a similar motion to storms upon the earth.

Some have supposed the body of the sun to be protected by the lower opake portion of the inner stratum of clouds, from the intense heat of the luminous strata, and thus rendered inhabitable; but several objections will at once arise to this theory. First, the body of the sun being surrounded by dense and opake clouds, could not send off its heat into space by radiation, and therefore the heat received from the clouds would accumulate and cause a high temperature. Second, the force of gravity being about thirty times as great as that of the earth, a common sized man would weigh some two or three tons; rendering it necessary to have an entirely different muscular organization. Third, it is improbable that living beings would be shut up within an impenetrable veil, and cut off from a knowledge of the planets, the stars, and the countless wonders existing in the boundless realms of space. These and other considerations render it probable that the sun is not inhabited.

SIGNS OF THE ZODIAC

SEPTEMBER
AUTUMNAL EQUINOX
THE EARTH ENTERS ARIES 23d SEP
AND AT THE SAME TIME THE SUN ENTERS
LIBRA

AUGUST
THE EARTH ENTERS PISCES 23d AUG
AND AT THE SAME TIME THE SUN ENTERS
VIRGO

JULY
THE EARTH ENTERS AQUARIUS 23d JULY
AND AT THE SAME TIME THE SUN ENTERS
LEO

JUNE
THE EARTH ENTERS CAPRICORNUS 21st JUNE AND AT THE SAME TIME
THE SUN ENTERS
CANCER

MAY
THE EARTH ENTERS SAGITTARIUS 21st MAY AND AT THE SAME TIME
THE SUN ENTERS
GEMINI

APRIL
THE EARTH ENTERS SCORPIO 20th APRIL
AND AT THE SAME TIME THE SUN ENTERS
TAURUS

MARCH
VERNAL EQUINOX
THE EARTH ENTERS LIBRA 21st MARCH
AND AT THE SAME TIME THE SUN ENTERS
ARIES

FEBRUARY
THE EARTH ENTERS VIRGO 19th FEBRUARY
AND AT THE SAME TIME THE SUN ENTERS
PISCES

JANUARY
THE EARTH ENTERS LEO 20th JANUARY
AND AT THE SAME TIME THE SUN ENTERS
AQUARIUS

DECEMBER
WINTER SOLSTICE
THE EARTH ENTERS CANCER 22d DEC.
AND AT THE SAME TIME THE SUN ENTERS
CAPRICORNUS

NOVEMBER
THE EARTH ENTERS GEMINI
23d NOV. AND AT THE SAME TIME
THE SUN ENTERS
SAGITTARIUS

OCTOBER
THE EARTH ENTERS TAURUS
23d OCTOBER AND AT THE SAME TIME
THE SUN ENTERS
SCORPIO

ARIES
PISCES
AQUARIUS
CAPRICORNUS
SAGITTARIUS
SCORPIO
LIBRA
VIRGO
LEO
CANCER
GEMINI
TAURUS

EARTH'S ORBIT

SUMMER SOLSTICE

AUTUMNAL EQUINOX

WINTER SOLSTICE

VERNAL EQUINOX

LESSON XIV.

ZODIAC.

Question. What is the Zodiac?

Answer. It is a circular belt in the heavens 16 degrees wide; 8 degrees on each side of the ecliptic.

Q. How is the zodiac divided?

A. It is divided into 12 equal parts, called signs or constellations of the zodiac.

Q. How is each sign divided?

A. Each sign is divided into 30 degrees; each degree into 60 minutes; each minute into 60 seconds, &c.

Q. What great circle is in the middle of the zodiac?

A. The ecliptic, or orbit of the earth.

Q. What are the names of the constellations of the zodiac and the signs of the ecliptic?

A. Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces.

Q. Do the constellations of the zodiac and the signs of the ecliptic occupy the same places in the heavens?

A. They do not: the signs in the ecliptic have fallen back of the constellations about 31 degrees.

Q. Did the constellations of the zodiac and signs of the ecliptic ever correspond?

A. They corresponded to each other about 22 centuries ago.

Q. What is the cause of the falling back of the signs of the ecliptic among the constellations?

A. It is caused by the retrograde motion of the equinoxes. (Note.)

Q. Upon what do the seasons depend?

A. They depend upon the revolution of the earth from one equinox to the same, again.

Q. Does the earth revolve around the sun in exactly the same time that it moves from one equinox to the same equinox again?

A. It moves from either equinox to the same again, seventeen minutes sooner, than around the sun.

LESSON XV.

Question. Does the sun appear to move in the heavens among the stars?

Answer. It has an apparent motion in the ecliptic, eastward around the heavens, during the year.

Q. How is this appearance caused, as the sun is in the centre, and does not move?

A. It is caused by the earth's moving around the sun.

Q. If the earth is in the sign Aries, where does the sun appear to be?

A. It appears to be in the opposite sign; *Libra!*

Q. As the earth moves around in the ecliptic, where does the sun appear to move?

A. It appears to move in the opposite part of the heavens, and in the opposite direction from the motion of the earth.

Q. Which sign does the sun enter, when the north pole leans exactly towards the sun?

A. Cancer. (21st June.)

Q. Which sign does the earth enter at this time?

A. Capricornus.

Q. Which signs does the sun enter, when the north pole leans sideways to the sun?

A. Aries and Libra.

Q. Which sign does the sun enter, when the north pole leans exactly from the sun?

A. Capricornus. (22d December.)

Q. Which are the equinoctial signs?

A. Aries, 21st of March—Libra, 23d of September.

Q. Which are the solstitial signs?

A. Cancer, 21st of June—Capricornus, 22d of December.

LESSON XVI.

Question. How are the signs of the ecliptic divided?

Answer. They are divided into four divisions, corresponding to the seasons.

Q. Which are the spring signs?

A. Aries, Taurus, Gemini.

Q. Which are the summer signs?

A. Cancer, Leo, Virgo.

Q. Which are the autumnal signs?

A. Libra, Scorpio, Sagittarius.

Q. Which are the winter signs?

A. Capricornus, Aquarius, Pisces.

Q. In what time do the equinoxes fall back through the whole circle of the Zodiac?

A. 25,800 years.

Q. What is this time called?

A. The Platonic, or great year.

Q. How is this motion caused?

A. It is caused by a slow annual motion of the earth's axis.

Q. What is longitude in the heavens?

A. It is the distance from the first degree of the sign Aries, reckoned eastward on the ecliptic, the whole circumference of the heavens.

Q. When the sun enters Aries, what is its longitude?

A. It has no longitude.

Q. What is the longitude of the earth at that time?

A. 180 degrees.

Q. When the sun enters Cancer, what is its longitude?

A. 90 degrees—the earth's longitude at the same time 270 degrees.

Q. When the sun enters Libra, what is its longitude?

A. 180 degrees—the earth's longitude 0 degrees.

Q. When the sun enters Capricornus, what is the longitude?

A. 270 degrees—the earth's longitude at the same time 90 degrees.

[Note.—This variation is caused by the pole of the earth varying a little every year. This motion of the pole of the earth is similar to that sometimes shown by a top, as it spins around on the point—The stem of the top will have a circular motion, describing a cone with the apex or top down. This circular motion of the pole of the earth is very slow, varying only 50″ every year, and requires 25,868 years to complete a revolution—which is called the Platonic or great year. The pole of the earth is increasing its distance from the north star and in 12,900 years it will be about 47° from it; and when the north star is on the meridian, it will be in the zenith of the northern part of the United States: but in 25,800 years the pole will have made a complete revolution—so that it will point again to the north star.]

DIRECT MOTION ← FROM WEST TO EAST.

VENUS

SUPERIOR CONJUNCTION

MERCURY

NOT VISIBLE IN THIS PART OF HIS ORBIT.

EAST

WEST

GREATEST ELONGATION 47° EAST.

GREATEST ELONGATION 30° EAST.

GREATEST ELONGATION 30° WEST.

GREATEST ELONGATION 47° WEST

STATIONARY.

STATIONARY.

STATIONARY.

STATIONARY.

INFERIOR CONJUNCTION.

RETROGRADE MOTION FROM EAST TO WEST.

EARTH

EARTH'S ORBIT.

TELESCOPIC VIEW OF VENUS.

VENUS A MORNING & EVENING STAR ALTERNATELY 290 DAYS

LESSON XVII.

MERCURY.

Question. WHICH planet is the smallest and nearest the sun?
Answer. Mercury.
Q. What is the diameter of Mercury?
A. 3,200 miles.
Q. What is its distance from the sun?
A. 37 millions of miles.
Q. What is its magnitude, compared with the earth?
A. It is $\frac{1}{17}$ of the earth's magnitude.
Q. What is the specific gravity of the planet Mercury?
A. It is about 15 times the weight of water. (15.111.)
Q. In what time does it revolve on its axis, or perform its daily revolution?
A. In about 24 hours. (24 hours 5 minutes.)
Q. In what time does it revolve around the sun?
A. In about 88 days. (87d. 23h. 14m. 33s.)
Q. How fast does it move in its orbit around the sun?
A. It moves 112,000 miles an hour.
Q. What is the light or heat at Mercury, compared with that of the earth?
A. It is about seven times as great.
Q. What is elongation?
A. It is the apparent distance of any planet from the sun.
Q. What is the greatest elongation of Mercury?
A. 30 degrees; which may be either east or west of the sun.
Q. Why is Mercury never seen in superior conjunction?
A. Because it is so much involved in the light of the sun.
Q. Does Mercury experience any change of seasons?
A. It does not, because its axis is perpendicular to its orbit. This causes the sun to be continually vertical at the equator.

LESSON XVIII.

VENUS.

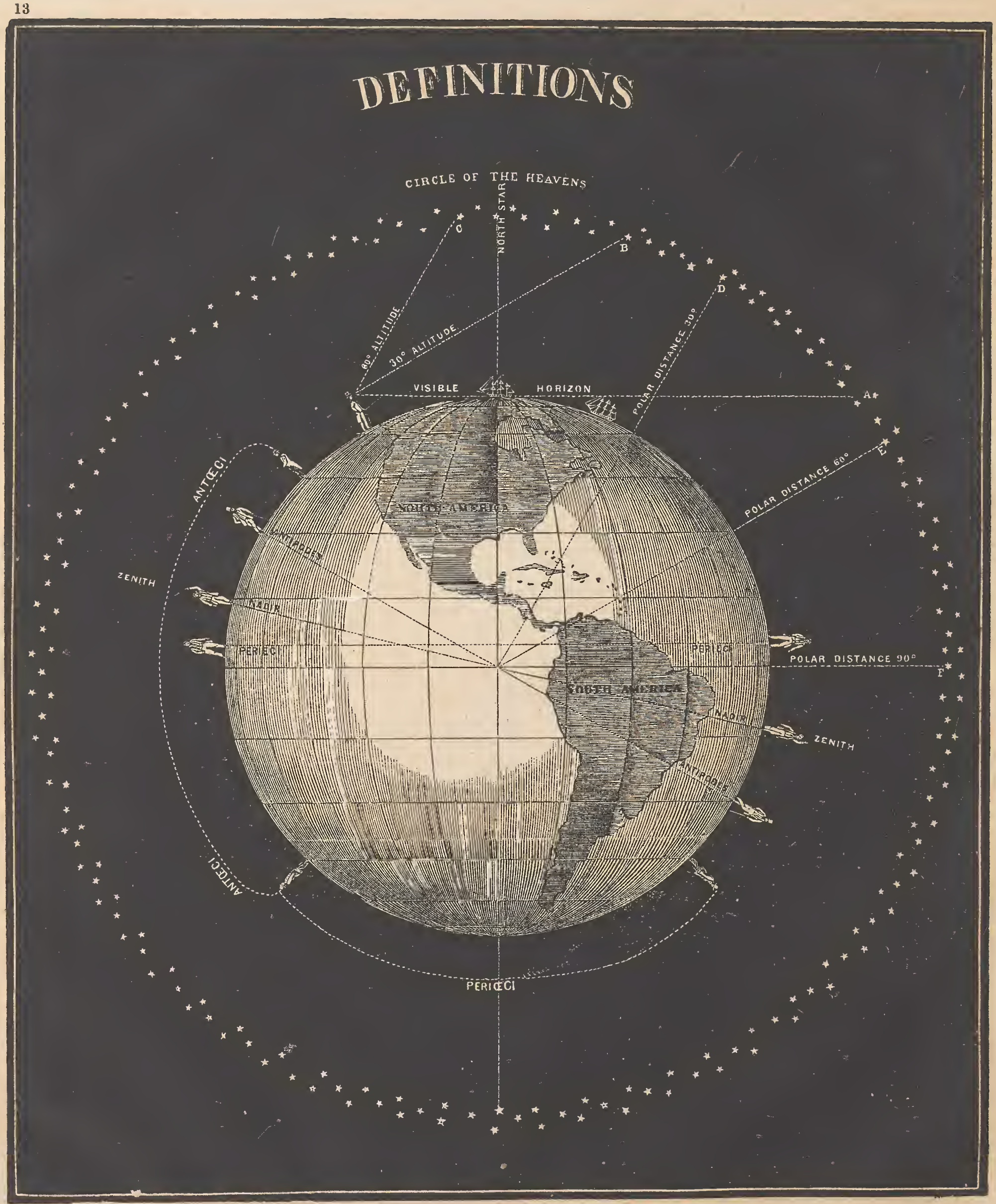
Question. WHAT planet is next to Mercury?
Answer. Venus.
Q. What is the diameter of Venus?
A. 7,700 miles.
Q. What is its distance from the sun?
A. 68 millions of miles.
Q. What is its magnitude compared with the earth?
A. It is about $\frac{9}{10}$ of the earth's magnitude.
Q. What is the specific gravity of Venus?
A. It is 5 times the weight of water. (5.058.)
Q. In what time does it revolve on its axis?
A. In about $23\frac{1}{2}$ hours. (23h. 21m.)
Q. In what time does it revolve around the sun?
A. In 224 days. (224d. 16h. 41m. 27s.)
Q. How fast does it move in its orbit around the sun?
A. It moves 75,000 miles an hour.
Q. What is the comparative light or heat at Venus?
A. It is about double that of the earth.
Q. What is the greatest elongation of Venus?
A. About 47 degrees.
Q. When is Venus a morning star?
A. When it is west of the sun, and rises before it.
Q. When is it an evening star?
A. When it is east of the sun, and sets after it.
Q. How long is Venus a morning or an evening star, alternately?
A. About 290 days.
Q. Why is Venus a morning or an evening star 66 days longer than the time of its revolution around the sun?
A. Because the earth is moving around the sun the same way.

[See diagram. If we suppose Venus to be in conjunction, or between the earth and sun, as they move the same way, Venus will move half around the sun, or 180 degrees, while the earth moves only 110 degrees. Venus will during this time be a morning star, and when Venus has completed its revolution around the sun, the earth will have passed through 220 degrees of its orbit, and Venus will still continue a morning star, although it has made a complete revolution around the sun. It will therefore have to make one complete revolution and 103 degrees over, before it can be seen on the other side of the sun; it will then be an evening star for the same length of time.]

LESSON XIX.

Question. How much is the axis of Venus inclined to that of its orbit?
Answer. 75 degrees.
Q. When the north pole of Venus inclines directly towards the sun, how many degrees will the axis point above the sun?
A. Only 15 degrees.
Q. How wide a torrid zone does this make?
A. 150 degrees—75 degrees on each side of the equator.
Q. The tropics are within how many degrees of the poles?
A. Within 15 degrees.
Q. The polar circles are within how many degrees of the equator?
A. 15 degrees.
Q. What is the diameter of the polar circles?
A. 150 degrees.
Q. Has Venus any variation of seasons?
A. She has two summers and two winters at the equator, and a summer and winter at each of the poles, during the year.
Q. How does Venus appear when viewed with a telescope?
A. She exhibits phases similar to those of the moon.
Q. How are conjunctions divided?
A. Into inferior and superior.
Q. When is a planet in inferior conjunction?
A. When it is between the earth and sun.
Q. What planets have inferior conjunction?
A. Mercury and Venus; also the moon.
Q. When is a planet in superior conjunction?
A. When it is beyond the sun.
Q. What planets have superior conjunction?
A. All, except the earth.
Q. When is a planet in opposition to the sun?
A. When it is on the opposite side of the earth.
Q. What planets have opposition?
A. The superior planets.
Q. What apparent motions have the planets?
A. Three; direct, stationary, and retrograde.
Q. When does a planet's motion appear to be direct?
A. When it appears to move from west to east among the stars.
Q. When is a planet's motion said to be stationary?
A. When it is moving directly towards or from the earth.
Q. When is a planet's motion said to be retrograde?
A. When it appears to move backwards, or from east to west among the stars.

DEFINITIONS



LESSON XX.

EARTH, DEFINITIONS, &c.

Question. What is the shape of the earth?

Answer. It is round like a globe or ball, a little flattened at the poles.

Q. How do we know the earth to be round?

A. 1st. Navigators have sailed round it, by a continued westerly or easterly course.—2d. The top-mast of a ship coming in from the sea, always appears first.—3d. The earth's shadow upon the moon, in a lunar eclipse, is circular.

Q. In what manner do the inhabitants stand upon the earth?

A. They stand with their feet directed towards the centre of the earth. (See Diagram.)

Q. What do you understand by the terms upward and downward?

A. Upward is from the centre of the earth, downward is towards the centre of the earth.

Q. What keeps the inhabitants, &c., upon the surface of the earth?

A. The attraction of the earth.

Q. What is the axis of the earth?

A. It is the straight line round which it performs its daily revolution.

Q. What are the poles of the earth?

A. They are the extremities of its axis.

Q. What is the equator?

A. It is a great circle, whose plane divides the earth into northern and southern hemispheres.

Q. To what is the plane of the equator perpendicular?

A. It is perpendicular to the earth's axis, and equidistant from the poles.

Q. What is the meridian of a place on the earth?

A. It is a great circle passing through the place, and the poles of the earth.

Q. Into what does the plane of the meridian divide the earth?

A. Into eastern and western hemispheres.

Q. What is the latitude of a place on the earth?

A. It is its distance from the equator, north or south.

Q. On what is it measured?

A. On a meridian?

Q. How far is latitude reckoned?

A. Ninety degrees?

Q. What places have 90 degrees of latitude?

A. The poles.

LESSON XXI.

Q. Which is the first meridian?

A. It is the meridian from which longitude is reckoned.

Q. Which meridian is generally used in this country as the first meridian?

A. The meridian of London.

Q. What is the longitude of a place on the earth?

A. It is its distance east or west of the first meridian.

Q. What angle expresses the longitude of a place?

A. The angle between the meridian of the place, and the first meridian.

Q. Where is this angle formed?

A. At the poles, where the meridians intersect each other.

Q. On what circle is this angle measured?

A. On the equator.

Q. How far is terrestrial longitude reckoned?

A. It is reckoned 180 degrees, or half round the earth.

Q. What is the horizon?

A. It is a great circle which separates the visible heavens from the invisible.

Q. How many horizons are there?

A. Two; the visible and the rational.

Q. What is the visible or sensible horizon?

A. It is that circle where the earth and sky appear to meet.

Q. What is the rational horizon?

A. It is a great circle, parallel to the visible horizon, whose plane passes through the centre of the earth.

Q. Into what does it divide the earth?

A. Into upper and lower hemispheres.

Q. Is the rational horizon above or below the visible horizon?

A. It is below the visible horizon.

LESSON XXII.

Q. Do all places on the earth have the same horizon?

A. They do not; if we change our place on the earth, the horizon changes.

Q. What are the poles of the horizon?

A. The zenith and nadir.

Q. What is the zenith?

A. It is that point in the heavens directly over our heads.

Q. Do all places have the same zenith?

A. They do not; every place has a different zenith.

Q. What is the nadir?

A. It is that point in the heavens which is opposite to the zenith, or directly under our feet.

Q. Are the zenith and nadir fixed points in the heavens?

A. They are not; they make a complete revolution in the heavens every 24 hours.

Q. What is the altitude of a heavenly body?

A. It is its height or distance from the horizon.

Q. What is the altitude of the star at A? (See Diagram.)

A. It has no altitude, being in the horizon.

Q. What is the altitude of the star at B? also at C? (See Diagram.)

Q. What is the polar distance of a heavenly body?

A. It is its distance from the pole.

Q. What is the polar distance of the star at D? also at E. and F? (See Diagram.)

Q. Who are the antipodes?

A. Those who live on directly opposite sides of the earth.

Q. Who are the antœci?

A. Those who live in equal latitude, on directly opposite sides of the equator.

Q. Who are the periœci?

A. Those who live in equal latitude on opposite sides of the pole.

Q. What peculiarity of circumstances have the antipodes?

A. They have opposite latitude, seasons, longitude, and day and night.

Q. What have the antœci?

A. They have opposite latitude and seasons, but the same longitude, and day and night.

Q. What have the periœci?

A. They have the same latitude and seasons, but opposite longitude, and day and night.

THE SEASONS.

FIG 1

FIG.2

FIG.3

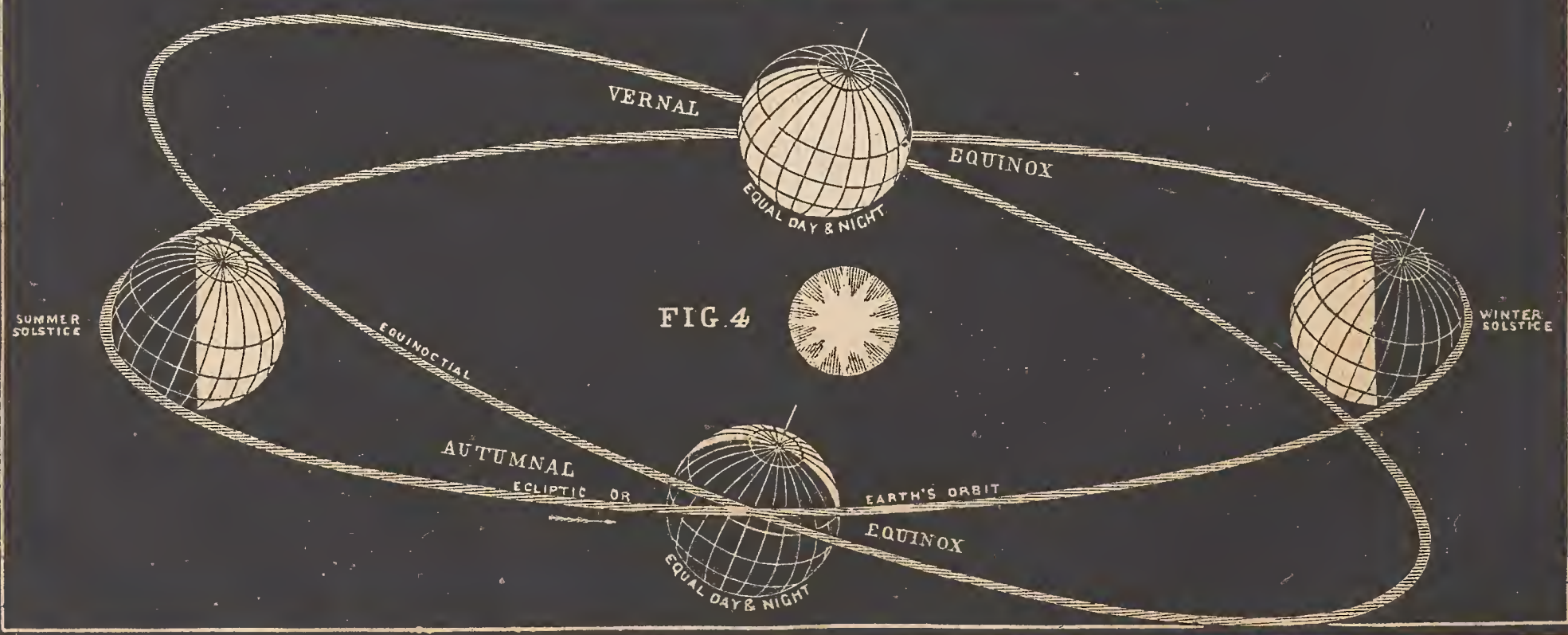


FIG.4

LESSON XXIII.

EARTH AND SEASONS.

Question. WHAT is the shape of the earth?

Answer. It is round like a globe or ball, a little flattened at the poles

Q. What is its position in the solar system?

A. It is the third planet from the sun.

Q. What is the mean diameter of the earth?

A. 7,912 miles. [Equatorial diameter 7,926 miles; polar diameter 7,899 miles.)

Q. How much greater is the equatorial than the polar diameter?

A. About 27 miles.

Q. What causes the equatorial diameter to be greater than the polar?

A. It is caused by the revolution of the earth on its axis.

[As the greater portion of the surface of the earth is covered with water; and as the earth revolves on its axis, the water recedes from the poles towards the equator, until its tendency to run back towards the poles, just balances the effects of the centrifugal force. This causes the equatorial diameter to be greater than the polar. If the earth should stop revolving on its axis, the water at the equator would settle away towards the poles, until the earth had assumed the form of a globe as near as possible. Thus large portions of land in the torrid zone, which are now covered by the ocean, would be left dry, and new continents and islands would be formed.]

Q. What is the mean distance of the earth from the sun?

A. About 95,000,000 of miles.

[The mean distance of a planet, is the distance it would always be from the sun, if its orbit should be reduced to a true circle.]

Q. What is the specific gravity of the earth?

A. It is 5½ times the weight of water. (5.48.)

Q. In what time does the earth revolve on its axis, or perform its diurnal revolution?

A. In 24 hours. (In 23 hours 56 minutes; as seen from the stars.)

Q. Which way does it revolve?

A. From west to east.

Q. What causes day and night?

A. The light of the sun causes day, and the shade of the earth causes night.

Q. How great a portion of the earth is continually in the light of the sun?

A. One half; the other half being in the shade of the earth.

Q. What does the revolution of the earth upon its axis, cause?

A. The succession of day and night.

LESSON XXIV.

Question. As the earth turns upon its axis, what effect is produced?

Answer. The sun is continually rising to places in the west, and continually setting to places in the east.

Q. In what time does the earth revolve around the sun, or perform its annual revolution?

A. In 365 days 6 hours.

Q. How fast does it move in its orbit around the sun?

A. 68,000 miles an hour.

Q. How are the changes of the seasons caused?

A. They are caused by the earth's axis being inclined to that of its orbit, and its revolution around the sun.

Q. How many degrees is the earth's axis inclined towards its orbit?

A. Twenty-three degrees and a half. (23° 28′.)

Q. Is the direction of the earth's axis changed during the year?

A. Its change is so slight that it may be considered as pointing to the same place in the heavens.

Q. When does the north pole lean directly towards the sun?

A. On the 21st of June, called the summer solstice. (See Diagram.)

Q. How many degrees does it lean towards the sun?

A. 23½ degrees; and the sun is vertical 23½ degrees north of the equator.

Q. What seasons does this produce?

A. Summer in the northern hemisphere, and winter in the southern.

Q. When does the north pole lean directly from the sun?

A. On the 22d of December, called the winter solstice. (See Diagram.)

Q. When the north pole leans from the sun, what are the seasons?

A. Winter in the northern hemisphere, and summer in the southern.

LESSON XXV.

Question. At what points of the ecliptic is the earth at the time of the solstices?

A. At the solstitial points.

Q. Through how much of its orbit does the earth pass, in moving from one solstitial point to the other?

A. One half of its orbit, or from one side of the sun to the other.

Q. What are those two points called half way between the solstitial points?

A. The equinoctial points. (See Diagram.)

Q. Why are they so called?

A. Because, when the earth is in these points, the sun is vertical at the equator, and the days and nights are every where equal.

Q. When is the sun at the vernal equinox?

A. On the 21st of March.

Q. When is it at the autumnal equinox?

A. On the 23d of September.

Q. Which way does the pole lean when the earth is at the eqinoctial points?

A. It leans sideways to the sun, the sun being vertical at the equator.

Q. When the north pole leans towards the sun, why is summer produced in the northern hemisphere?

A. Because the rays of the sun strike it so directly as to cause many rays to fall on a given surface.

Q. When the north pole leans from the sun, why is winter produced in the northern hemisphere?

A. Because the rays of the sun strike it so obliquely, that they spread over a greater surface.

Q. At what points do the ecliptic and equinoctial intersect each other?

A. At the equinoctial points. (See Diagram.)

Q. How far are the solstitial points from the equinoctial points?

A. Ninety degrees.

MARS & JUPITER

TELESCOPIC VIEWS OF JUPITER

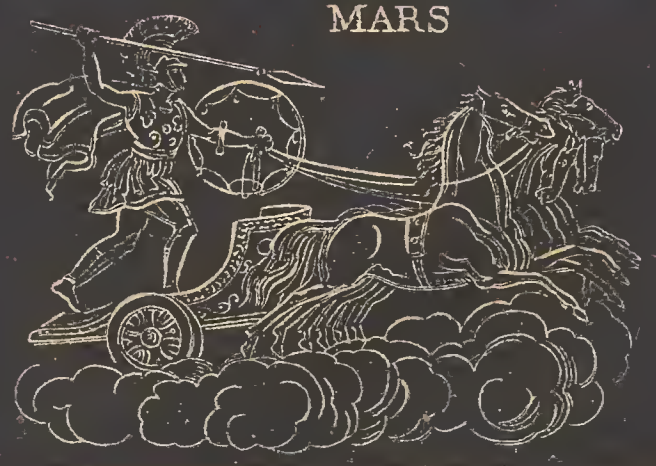
FIG. 1&2

FIG 3

JUPITER

TELESCOPIC VIEWS OF MARS

MARS



LESSON XXVI.

MARS.

Question. WHAT is Mars?

Answer. Mars is the fourth planet from the sun.

Q. What can you say of its size?

A. It is the smallest except Mercury and the asteroids.

Q. What is its diameter?

A. 4,189 miles.

Q. What is its distance from the sun?

A. 142 millions of miles.

Q. What is its magnitude?

A. It is about one-seventh of the size of the earth.

Q. What is the specific gravity of Mars?

A. It is about five times the weight of water. (5.19.)

Q. In what time does it revolve on its axis?

A. In about 24½ hours. (24h. 39m. 22s.)

Q. In what time does it revolve around the sun?

A. In one year, 321 days.

Q. How fast does it move in its orbit?

A. 55,000 miles an hour.

Q. How many degrees does the axis of Mars lean towards its orbit?

A. About 30 degrees, (30° 18′.) (See Diagram.)

Q. Does Mars have any change of seasons?

A. The seasons are similar to those of the earth, but nearly twice as long.

Q. Why are they longer?

A. Because Mars is nearly two of our years in revolving around the sun.

Q. What is the appearance of Mars when seen with the naked eye?

A. It appears of a red, fiery color.

LESSON XXVII.

Q. How does Mars appear when viewed with a telescope?

A. Outlines of apparent continents and seas, are distinctly seen.

Q. What appearance have the continents?

A. They have a ruddy color, arising probably from the nature of the soil.

Q. Of what color are the seas?

A. They appear of a greenish color, caused no doubt by contrast with the red color of the continents.

Q. Does Mars present different phases?

A. It sometimes appears gibbous.

Q. When does a planet appear gibbous?

A. When we can see more than half, but not the whole, of the illuminated surface.

Q. Does Mars ever appear horned like the moon?

A. It does not, because it does not pass between us and the sun.

Q. What other appearances does Mars exhibit when viewed with a telescope?

A. Bright spots are seen alternately at the poles.

Q. When do these spots appear?

A. When it is winter, or continual night at the poles.

Q. What is supposed to be the cause of these spots?

A. Snow and ice, which has accumulated at the poles during winter.

Q. Do these spots continue through the year?

A. They entirely disappear as the summer advances upon the poles.

Q. What amount of light and heat has Mars?

A. It has about half as much as the earth.

LESSON XXVIII.

JUPITER.

Question. WHAT is Jupiter?

Answer. Jupiter is the largest planet in the solar system.

Q. How many times larger is Jupiter than the earth?

A. It is 1,280 times greater.

Q. What is the specific gravity of Jupiter?

A. It is about 1⅓ times the weight of water. (1.30.)

Q. How far is Jupiter from the sun?

A. 485 millions of miles.

Q. What is its diameter?

A. 87,000 miles.

Q. Which diameter is the greater, the polar or equatorial?

A. The equatorial diameter is 6,000 miles greater than the polar.

Q. What causes the equatorial diameter, so much to exceed the polar?

A. The quick rotation of the planet upon its axis.

Q. In what time does it revolve upon its axis?

A. In about 10 hours. (9h. 55m. 50s.)

Q. In what time does it revolve around the sun?

A. In eleven years, 314 days.

Q. How fast does it move in its orbit around the sun?

A. 30,000 miles an hour.

Q. How many moons has Jupiter?

A. Four.

Q. Has Jupiter any change of seasons?

A. It has no change of seasons.

Q. Why do its seasons not change?

A. Because its axis is nearly perpendicular to the plane of its orbit, which causes the sun to be always vertical at the equator. (See Diagram.)

Q. How does Jupiter appear, when viewed with a telescope?

A. Light and dark belts appear to surround it. (See Fig. 1 and 2.)

Q. What are the light belts?

A. They are supposed to be clouds, which are thrown into parallel lines by the quick rotation of the planet upon its axis.

Q. What are the dark belts?

A. They are probably the body of the planet, seen between the clouds.

Q. Do these belts always appear the same?

A. They change frequently, and sometimes the clouds break to pieces. (See Fig. 3.)

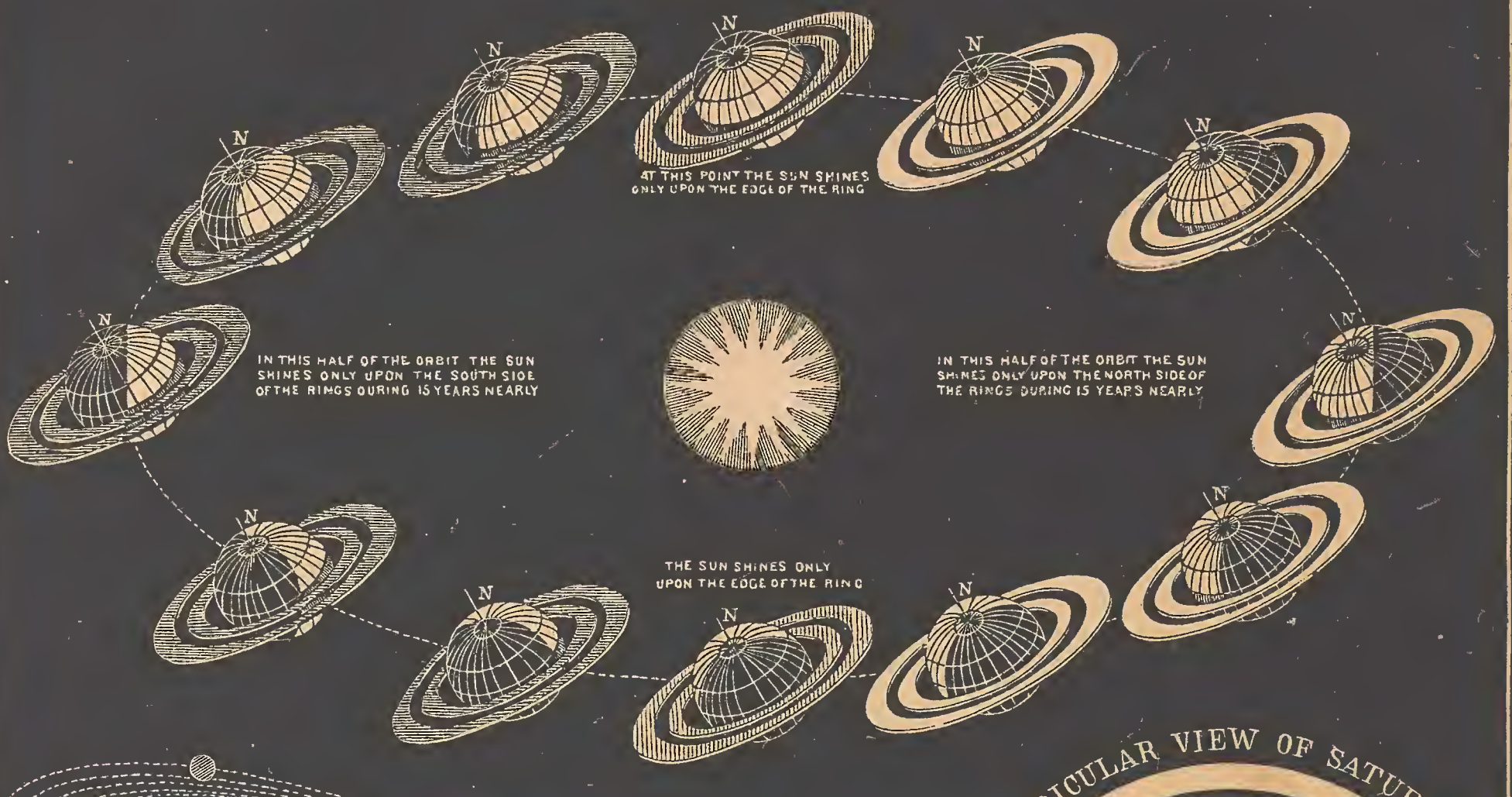
Q. What is the velocity of its equatorial parts, in turning on its axis?

A. 25,000 miles an hour.

Q. What amount of light and heat has Jupiter?

A. It has 27 times less than the earth.

SATURN



SATURN

A VIEW OF SATURN'S RINGS AND MOONS AS SEEN FROM THE PLANET AT MIDNIGHT
THE DARK SHADE IS THE SHADOW OF THE PLANET UPON THE RINGS

LESSON XXIX. 29.

SATURN.

Question. What is Saturn?

Answer. It is the largest planet except Jupiter.

Q. What is its magnitude compared with the earth?

A. It is about 1,000 times larger.

Q. What is its specific gravity?

A. It is about one half the weight of water. (0.56.)

Q. What is the diameter of Saturn?

A. 79,000 miles.

Q. What is its distance from the sun?

A. 890 millions of miles.

Q. In what time does it revolve on its axis?

A. In about 10½ hours. (10h. 29m. 16s.)

Q. In what time does it revolve around the sun?

A. In 29 years and a half. (29y. 167d.)

Q. How fast does it move in its orbit around the sun?

A. 22,000 miles an hour.

Q. Is there any change of seasons at Saturn?

A. There is, but it is very slow, as it takes nearly thirty of our years, to complete a year at Saturn.

Q. How much does the axis of Saturn lean towards its orbit?

A. About 30 degrees. (28° 40′.) (See Diagram.)

Q. How long is it day and night alternately at the poles?

A. About 15 of our years. (See Diagram.)

Q. What has Saturn which surrounds it?

A. Two large rings of solid matter like the planet. (See Diagram.)

Q. What is their position around the planet?

A. They are directly over the equator.

LESSON XXX. 30.

Q. Do these rings revolve with the planet!

A. They do, and in nearly the same time as the planet.

Q. Are these rings connected with the planet or separate?

A. They are separate from the planet and from each other.

Q. What is the distance from the planet to the inner ring?

A. 19,000 miles.

Q. How wide is the inner ring?

A. 17,000 miles.

Q. How wide is the space between the rings?

A. About 1,800 miles.

Q. What is the width of the outer ring?

A. 10,000 miles.

Q. How thick are these rings?

A. About 100 miles. (Some say 1,000 miles.)

Q. Are these rings uniform?

A. They are rough and uneven.

Q. How many satellites or moons has Saturn?

A. Seven.

Q. What is the position of their orbits?

A. Their orbits, excepting one, are directly over the rings. (See Diagram.)

Q. Does the sun always shine on the same side of the rings?

A. It shines upon each side alternately for fifteen years. (See Diagram.)

Q. What amount of light and heat has Saturn?

A. It has 90 times less than the earth.

Q. What appearance has the disc of Saturn!

A. It has dark belts similar to those of Jupiter.

Saturn.

According to heathen mythology, Saturn was the deity who presided over time. He is sometimes represented as an old man, flying with wings attached to his back; carrying an hour-glass in one hand, and a scythe in the other. These are very appropriate emblems of time; the old man represents time, his flying admonishes us to improve every moment as it comes, or it will be lost; the hour-glass reminds us that our life, like the sand in the glass, will soon run out; and the scythe, like time,

"Cuts down all,
Both great and small."

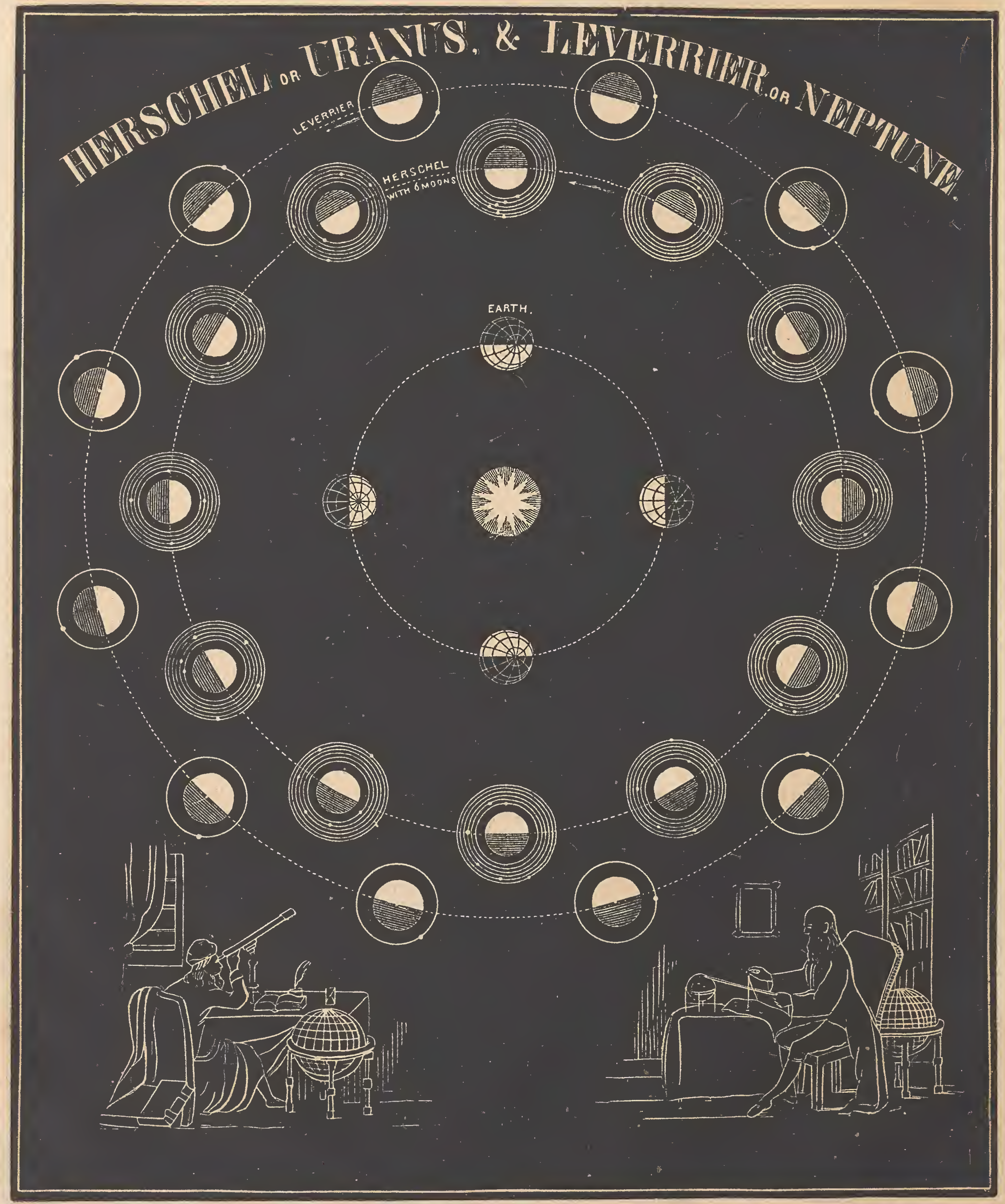
Saturn is the fourteenth planet from the sun, and the most remarkable; it is next in order to Jupiter, and the most remote planet from the earth, of any that are visible to the naked eye. It may easily be distinguished from the fixed stars by its pale, feeble and steady light. It is 890 millions of miles from the sun, and revolves around it in 29 years 167 days; so that its apparent motion among the stars is very slow, being only 12 degrees in a year. Saturn, besides being attended with seven moons, is surrounded by two large concentric rings, which are separate from each other, and also from the planet. The matter, of which these rings are composed, is undoubtedly no less solid than the planet, and they are observed to cast a strong shadow upon the planet itself. Saturn, in bulk, is about 1,000 times larger than the earth, and revolves on its axis in 10h. 29m. 16s. This rapid motion upon its axis, causes it to be, like Jupiter, very much flattened at the poles. So that the equatorial diameter is to the polar, as 12 to 11. The rings of Saturn present a phenomenon, to which there is nothing analagous in the rest of the solar system. These rings are very thin, one within the other, and directly over the equator. They revolve round in the same time with the planet, although they are detached from it.

The axis of Saturn is inclined to that of it's orbit 28° 40′, and as the rings are in the plane of the equator, the axis of the rings has the same inclination. It will be seen from this, (see Diagram,) that the sun shines alternately for 15 years on one side of the rings, and then upon the other; so that if we lived upon the rings, we should have continued day for 15 years, and then continual night for the same length of time.

The rings of Saturn must present to the inhabitants of the planet a most magnificent spectacle. They appear like vast arches, or semicircles of light, extending from the eastern to the western horizon. At the equator, the outer ring is not visible, being hidden from the view by the inner ring; but, in about 45 degrees of latitude, both rings are visible, and present a magnificent appearance. During the day-time, they appear dim like a white cloud, but, as the sun goes down their brightness increases; while the shadow of the planet is seen to come on at the eastern limb of the ring, and gradually rise to the zenith, (see Diagram,) when it passes down and disappears in the western horizon at the rising of the sun. The rays of the sun always fall upon the sides of the rings very obliquely, as the sun is never seen more than 30 degrees above the horizon of the rings, while at other times the edge of the rings only is presented to the sun. (See Diagram.) These rings are rough and of unequal width and thickness, and it has been demonstrated that these rings could not maintain their stability of rotation, if they were in all parts of equal thickness and density, as the smallest disturbance would destroy their equilibrium, which would continue to increase until at last, they would be precipitated upon the planet.

Saturn has seven moons, or satellites, but they are only seen with a good telescope. Their orbits, with the exception of the seventh, are nearly in the plane of the rings; the seventh, which is the farthest from the planet, is the largest, and its orbit is considerably inclined to the plane of the rings. (See Diagram.)

HERSCHEL OR URANUS, & LEVERRIER OR NEPTUNE.



LESSON XXXI.

HERSCHEL, OR URANUS.

Question. When was Herschel or Uranus discovered?
Answer. In 1781.

Q. By whom?
A. By Sir William Herschel, who was a celebrated English astronomer.

Q. In what part of the solar system is Herschel situated?
A. It is the fifteenth planet from the sun, and next to the farthest discovered.

Q. What is its magnitude?
A. It is 80 times larger than the earth.

Q. What is its specific gravity?
A. It is $1\frac{1}{2}$ times the weight of water. (1.53.)

Q. What is its distance from the sun?
A. 1800 millions of miles.

Q. In what time does it revolve on its axis?
A. It is not certainly known. [It has been stated at 1 day 18 hours, but there seems to be no proof of it.] *Professor Nichol.*

Q. In what time does it revolve around the sun?
A. In about 84 years. (84*y*. 6*d*.)

Q. How fast does it move in its orbit around the sun?
A. 15,000 miles an hour.

Q. How will the light and heat at Herschel, compare with the same at the earth?
A. They are 368 times less.

Q. How many moons has Herschel?
A. Six moons were seen by Sir Wm. Herschel, but only three have been seen by other astronomers.

Q. What angle do the orbits, of the two which are best known, make with the ecliptic?
A. An angle of 78 degrees. (78° 58′.)

Q. In what direction do these moons move in their orbits?
A. They move from east to west, contrary to the motions of all the other planets, both primary and secondary.

LESSON XXXII.

LEVERRIER, OR NEPTUNE.

Q. When was Neptune discovered?
A. In 1846, by Dr. Galle, of Berlin.

Q. Who published the elements of this planet, and directed astronomers to the point in the heavens where it might be discovered?
A. Leverrier, a celebrated French mathematician.

Q. How near the point, where he directed astronomers to look, was it found?
A. Within one degree.

Q. What is the diameter of this planet?
A. It is about 35,000 miles.

Q. What is its magnitude?
A. It is about 80 times larger than the earth.

Q. What is its distance from the sun?
A. About 2,850 millions of miles.

Q. In what time does it revolve on its axis?
A. It is not known.

LEVERRIER, OR NEPTUNE.—Continued.

Q. In what time does it revolve around the sun?
A. In about 166 years.

Q. How many moons has Leverrier?
A. One; and another is supposed to have been seen.

Q. What amount of light and heat has this planet?
A. About 900 times less than that of the earth.

Q. Does this planet correspond to the calculations of Leverrier, as to mass and distance from the sun?
A. Its mass and distance are considerably less than his calculations.

Q. What have these circumstances led some astronomers to suppose?
A. That Leverrier is one of a group of planets similar to the Asteroids, situated at nearly the same distance from the sun.

Q. Are the primary planets inhabited?
A. They appear to be inhabitable.

[Note.—The presence of clouds indicating both air and water; the regular succession of the seasons, as well as day and night; the suitable amount of light received from the sun; the accompaniment of moons; the specific gravity of bodies at their surface; all seem to indicate that the primary planets are suitable residences for living beings. The only objection to this view is, the difference in the amount of heat received from the sun, supposing it to be according to the inverse ratio of the squares of their distances from the sun. But we see from the difference of temperature on the earth, at the base and summit of high mountains, that the actual heat depends much upon the modifying circumstances, as well as upon the direct rays of the sun. And we have reason to suppose that the temperature of the other planets does not differ much from that of the earth.

For instance, the temperature of Mars, as indicated by the melting of its snow, and that of Jupiter and Saturn, as indicated by the amount of vapor in their atmosphere, appear to be similar to that of the earth. Mercury and Venus are protected from the direct rays of the sun by dense clouds. Causes unknown to us, may and probably do, modify the temperature of all the planets in a greater or less degree, sufficiently so, for the purposes of animal life.]

HERSCHEL.

This planet was discovered by Sir William Herschel, March 13th, 1781. It had been observed by Flamstead, Mayer, Tycho Brahe, and other astronomers, and was regarded by them as a fixed star, and such it was considered by Dr. Herschel, until he discovered it to be a planet, from its having moved from the place where he had observed it some time before.

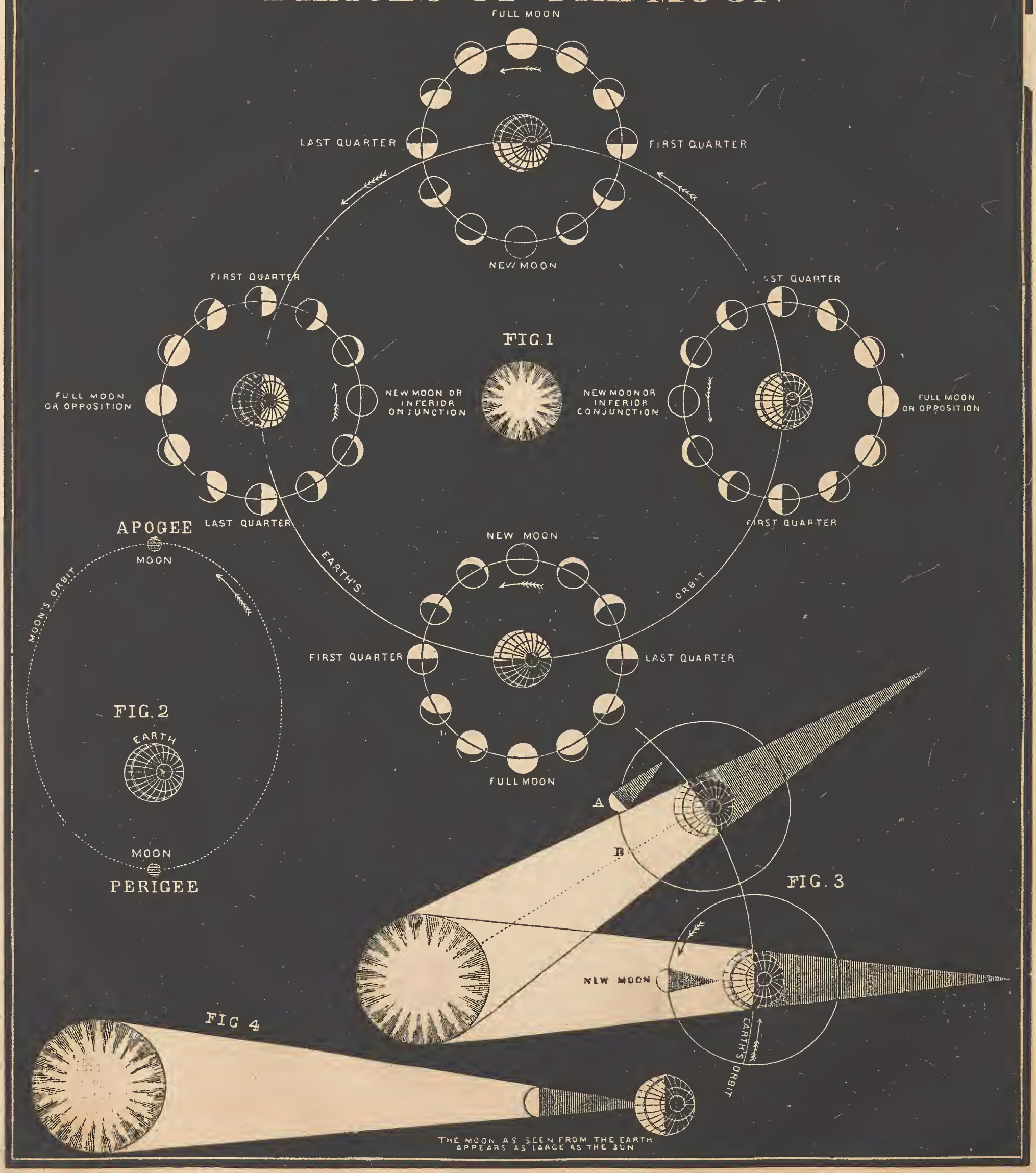
Sir William Herschel gave it the name of "*Georgium Sidus*, or Georgian Star," in honour of his Royal patron, George III., but the Royal Academy of Prussia, called it Uranus.

THE NEW PLANET.

CAUSE WHICH LED TO ITS DISCOVERY.

It had been found by observation, that the attraction of the planets upon each other, accelerate or retard the motion of each. These variations have been well understood by astronomers for many years; but it was found by a series of observations made during several years upon the planet Herschel, that its motion in the heavens was affected by some cause other than that of Saturn or Jupiter. This led astronomers to suspect that there might be another planet, either between the orbits of Saturn and Herschel, or beyond that of Herschel. *Leverrier*, having collected the observations of the most celebrated astronomers for many years, was enabled, by his profound knowledge of the mathematics, to calculate its elements.

PHASES OF THE MOON



LESSON XXXIII.

MOON.

Question. WHAT is the moon?

Answer. The moon is a secondary planet, revolving around the earth.

Q. Is the moon larger or smaller than the earth?

A. It is 49 times less than the earth.

Q. What is the diameter of the moon?

A. 2,180 miles.

Q. What is the specific gravity of the moon?

A. It is $3\frac{1}{2}$ times the weight of water, (3.37.)

Q. What is its mean distance from the earth?

A. Two hundred and forty thousand miles.

Q. In what time does the moon revolve around the earth?

A. In about $27\frac{1}{2}$ days, ($27d.\ 7h.\ 43m.\ 11s.5.$)

Q. In what time does the moon revolve upon its axis?

A. In about $27\frac{1}{2}$ days, or in the same time that it revolves around the earth.

Q. What is the result of the moon's revolving upon its axis and around the earth in the same time?

A. The same side of the moon is always presented to the earth.

Q. Have we ever seen the opposite side of the moon?

A. We have not.

Q. What causes the moon always to present the same side to the earth?

A. It is supposed that one side of the moon is more dense than the other, consequently the centre of gravity is not in the centre of the moon.

Q. What is a lunation, or lunar month?

A. It is the time from one new moon to another.

Q. What is the length of a lunation?

A. About $29\frac{1}{2}$ days. ($29d.\ 12h.\ 44m.$)

Q. Why is a lunation longer than the time it takes the moon to revolve around the earth?

A. Because the earth is revolving around the sun at the same time. (Fig. 3. See Note 1.)

LESSON XXXIV.

Q. What is the length of the days or nights at the moon?

A. About 15 of our days. (Note 4.)

Q. Which way does the moon revolve around the earth?

A. From west to east.

Q. If the moon revolves from west to east, what causes it to rise in the east?

A. It is caused by the earth's revolving on its axis the same way. (Note 2.)

Q. Does the moon rise the same hour every evening?

A. It rises about 50 minutes later every day.

Q. What is the cause of its rising 50 minutes later every day?

A. It is caused by the moon's revolving around the earth from west to east.

Q. What causes the phases of the moon, from new moon to new moon again?

A. It is caused by the moon's revolving around the earth. (See Diagram. Note 3.)

Q. When is it new moon?

A. When the moon is between the earth and sun, and the dark side is presented to us. (Fig. 1.)

MOON.—Continued.

Q. When is it full moon?

A. When the moon is upon the opposite side of the earth from the sun, and the illuminated side is presented to us. (Fig. 1.)

Q. How much greater is the light of the sun than the full moon?

A. 300,000 times greater.

Q. When are the sun and moon in quadrature?

A. When they are ninety degrees distant from each other. (Fig. 1.)

Q. How much of the illuminated side of the moon is visible to us when it is in quadrature?

A. One-half. (Fig. 1.)

Q. How much larger is the sun than the moon?

A. 70 millions of times greater.

Q. Why does the moon appear as large as the sun?

A. Because it is four hundred times nearer to us than the sun. (See Fig. 4.)

Note 1. *Fig.* 3.—The moon revolves around the earth in about $27\frac{1}{3}$ days, but from one new moon to another it is about $29\frac{1}{2}$ days; this difference is caused by the earth's revolving around the sun at the same time that the moon is revolving around the earth. This will appear plain by examining Fig. 3, on the opposite page. If we suppose the moon to be in conjunction or new moon, while the moon is revolving around the earth, the earth moves through nearly one-twelfth part of its orbit, and when the moon arrives at A, it will have made a complete revolution around the earth; but the moon will not be in conjunction, or between the earth and sun, until it has moved the distance from A to B—hence it will be seen that from one new moon to another the moon has to make more than one complete revolution around the earth.

Note 2.—That the moon revolves around the earth from west to east, from one new moon to another in about $29\frac{1}{2}$ days, there is not the least doubt; and it will appear perfectly plain if we consider that the earth is revolving on its axis the same way, or from west to east; the earth revolves on its axis in 24 hours, whereas the moon is $29\frac{1}{2}$ days in revolving around the earth; consequently the moon only moves from west to east in 24 hours, as much as the earth turns on its axis in 50 minutes, which makes the moon rise as much later every evening. If the earth did not revolve upon its axis, then the moon would rise in the west, and after being above the horizon for nearly 15 days, would set in the east, and would be below the horizon for the same length of time, when it would rise again in the west.

PHASES OF THE MOON.

Note 3. *Fig.* 1.—By phases of the moon is meant the various appearances which the moon presents from new to full moon, and from full moon to new moon again. As the moon is a dark body of itself, there is only one-half of its surface illuminated by the sun. At new moon, when the moon is between the earth and sun; that side of the moon upon which the sun shines, is towards the sun, and the dark side is presented to the earth; consequently we do not see any portion of the illuminated side of the moon at new moon, *see Fig.* 1; but as the moon passes around from west to east, it brings the illuminated side of the moon more and more to our view; at the first quarter we can see one-half of the illuminated surface; and when the moon arrives at full moon, we can see the whole of the illuminated surface, as the earth is then between the sun and moon. From full moon to new moon again, the illuminated surface disappears in the same manner as it appeared.

LENGTH OF THE DAYS AND NIGHTS AT THE MOON.

Note 4. As the moon revolves on its axis only once in its revolution around the earth, it continually presents the same side to the earth, and there would be, consequently, only one day and night in each revolution of the moon around the earth, or the day and night would each be nearly fifteen days long.

TELESCOPIC VIEW OF THE NEW MOON

LESSON XXXV.

MOON.—Continued.

Question. Has the moon an atmosphere?

Answer. Very little if any.

Q. What is the appearance of the moon when viewed with a telescope?

A. It appears covered with light and dark spots of various shapes.

Q. What is the cause of this appearance?

A. It is caused by the mountains, plains and valleys in the moon.

Q What are the light spots?

A. Mountains and elevated land.

Q. What are the dark spots?

A. Plains, valleys, &c.

Q. Has the moon any oceans, seas, or large bodies of water?

A. Not upon the side towards the earth.

Q. If you were living upon this side of the moon, what would be the appearance of the earth?

A. The earth would appear like a large stationary moon.

Q. How much larger than the moon appears to us?

A. Thirteen times greater.

Q. In what time would the heavenly bodies appear to revolve around the moon?

A. The stars would appear to revolve in 27½ days, the sun in 29½ days.

Q. What is the shape of the moon's orbit?

A. Elliptical, or one diameter greater than the other. (*See Diagram*, page 24.)

Q. What is apogee?

A. It is the point in the orbit of the moon farthest from the earth.

Q. What is perigee?

A. It is the point in the orbit of the moon nearest to the earth.

Q. When is the moon in apogee?

A. When it is at its greatest distance from the earth.

Q. When is the moon in perigee?

A. When it is nearest to the earth.

Q. Has the moon any change of seasons?

A. None, except those changes which take place every lunar month.

Q. What is the harvest moon?

A. When the moon is full in September and October, it rises only a few minutes later for several successive evenings, and thus affords light for collecting the harvest, it is therefore called the harvest moon.

Q. What is the cause of the harvest moon?

A. It is caused by the moon's orbit being very oblique to the horizon.

Q. Is the moon inhabited?

A. The want of air and water, render it uninhabitable by beings like ourselves.

PHYSICAL CONSTITUTION OF THE MOON.

In viewing the moon with the naked eye, her disc appears diversified with dark and bright spots, which on being examined with a powerful telescope are discovered to be mountains and valleys. The whole surface of the moon is covered with these spots, which is evident from the fact that the line of separation between the illuminated and dark hemispheres, is at all times extremely ragged and uneven. The mountains on or near this line cast behind them long black shadows, like the mountains on the earth when the sun is rising or setting. The moon is a much more mountainous body than the earth, and the mountains are vastly higher compared with its size than those of the earth. One of the mountains (*named Tycho*) situated in the southeast part of the Moon, is apparently a volcanic crater 50 miles in diameter, and 16,000 feet deep, with a central mountain rising to the height of 5,000 feet. The height of ten of the principal mountains, according to the recent measurement of Mædler, is from 3½ to 4¾ miles. The mountains of the moon do not run in ranges like those of the earth; but are single peaks scattered over nearly the whole surface of the moon, and are generally of a circular form shaped like a cup. These facts substantially prove the mountains of the moon to be of volcanic origin, and in some of the principal ones, decisive marks of volcanic stratification, arising from successive deposites of ejected matter, may be distinctly traced with powerful telescopes—The moon contains no large bodies of water, such as, oceans, seas, &c., especially upon the side visible to us. If there are any, they must be upon the opposite side of the moon which is never presented to us. The moon also has very little if any atmosphere, at least, none of sufficient density to refract the rays of light in their passage through it: from these two circumstances there are no clouds floating around the moon: if there were any, they would at times be visible to us, but none have been observed, it presents the same appearance that it did 2,000 years ago; no trace of vegetation or change of seasons has been observed, every thing appears solid, desolate, and unfit for the support of animal or vegetable life. Whether the materials of which the moon is composed, are of the same nature as the earth, there are no means of knowing. From the effect of the moon's gravitation in producing the nutation of the earth's axis, the mass of the moon is determined to be very nearly 1.80th of the mass of the earth, whence, as her volume is 1.49th of the earth's volume, it follows that her density as compared with the mean density of the earth is .615 or a little more than one half; consequently the materials of which the moon is composed are about half as heavy as the same bulk of the earth.

There being little or no atmosphere about the moon, the heavens, in the daytime, have the appearance of night to the inhabitants of the moon, when they turn their backs to the sun; and the stars then appear, as bright to them as they do in the night to us; for it is entirely on account of the light which our atmosphere reflects that the heavens appear luminous about us in the daytime. If our atmosphere were removed, only that part of the heavens would be light in which the sun is situated; and if we turned our backs to the sun the heavens would appear as dark as night. The light which the full moon affords us is very small, when compared with the light of the sun; it being 300,000 times less. It has also been demonstrated that the light reflected by the moon produces no heat; as its rays, when collected by the aid of the most powerful glasses, have not been perceived to produce the slightest effect upon the thermometer.

IS THE MOON INHABITED?

From the physical constitution of the moon, it is evident that the moon is not inhabited; at least, by beings constituted like ourselves. The moon having no atmosphere, we could not maintain an existence upon its surface for a single hour; even if it is provided with the other necessary means for our existence: neverthless, this is not conclusive evidence that the moon is not inhabited. The same power that called the moon into existence could as easily constitute beings fitted to inhabit its surface, and enjoy an existence like that of ours. It may be very properly asked—if the moon is not a habitable body, for what purpose was it created? This is a question which is more easily asked than answered. We do know that it exerts a powerful influence in raising the tides, and how far this influence operates upon the animal and vegetable kingdoms, we are unable to decide; its influence is no doubt felt to a greater or less extent.

TELESCOPIC VIEW OF THE FULL MOON

NORTH

EAST

WEST

SOUTH

TELESCOPIC VIEW OF THE MOON

PAST THE LAST QUADRATURE

LESSON XXXVI.

ECLIPSES.

Question. What is an eclipse?

Answer. It is the interception of the sun's rays by some opake body.

Q. How are eclipses divided, with respect to the body eclipsed?

A. Into two kinds, solar and lunar.

Q. What is a solar eclipse?

A. It is an eclipse of the sun.

Q. What is the cause of an eclipse of the sun?

A. It is caused by the moon's passing between the earth and sun, and casting its shadow upon the earth. (Fig. 3.)

Q. When must an eclipse of the sun take place?

A. It can happen only at new moon.

Q. What is a lunar eclipse?

A. It is an eclipse of the moon. (Fig. 3.)

Q. What causes an eclipse of the moon?

A. It is caused by the moon's passing through the earth's shadow. (Fig. 3.)

Q. When must an eclipse of the moon take place?

A. It can happen only at full moon. (Fig. 3 and 4.)

Q. How are eclipses divided, with respect to the amount eclipsed?

A. Into total and partial.

Q. What is a total eclipse?

A. It is an eclipse of the whole of the sun or moon. (Fig. 3 and 8.)

Q. What is a partial eclipse?

A. It is an eclipse of only a part of the sun or moon. (Fig. 7.)

Q. What is an annular eclipse?

A. It is an eclipse of the central part of the sun, when the moon is so far from the earth, that the sun can be seen like a bright ring around it. (Fig. 9, Note.)

Q. Do we have an eclipse of the sun at every new moon?

A. We do not.

Q. Why do we not have an eclipse of the sun at every new moon?

A. Because at new moon, the moon is generally too high or too low for its shadow to fall upon the earth. (Fig. 5.)

Q. Do we have an eclipse of the moon at every full moon?

A. We do not; at full moon the moon generally passes above or below the earth's shadow.

Q. What is the length of the earth's shadow?

A. About 600,000 miles. (Note. This is the mean or average length.)

Q. What is the length of the moon's shadow?

A. About 234,000 miles. (Note. This is the mean or average length.)

Q. What is a digit?

A. It is the twelfth part of the apparent diameter of the sun or moon's disc. (Fig. 6.)

Q. What is the greatest number of eclipses that can take place in a year?

A. Seven; five of the sun and two of the moon.

Q. What is the least number of eclipses that can take place in a year?

A. Two; and both must be of the sun.

ECLIPSES.

All opake bodies cast a shadow when the rays from any luminous body fall upon them. Every primary and secondary planet in the solar system casts a shadow towards that point of the heavens which is opposite to the sun. If the sun were smaller than the earth, the earth's shadow would increase in diameter as the distance increases from the earth, (See Fig. 1;) but if the sun and earth were of the same size, the shadow would be of the same size, no matter how great the distance from the earth, (See Fig. 2.) But as the sun is immensely larger than the earth, the earth's shadow terminates in a point at about 600,000 miles from the earth; the length of the earth's shadow is, however, subject to considerable variation. When the earth is nearest to the sun, which takes place about January 1st, the shadow is much shorter than when the earth is at its greatest distance, which is about the 1st of July. The moon revolves around the earth in about 29½ days, from one new moon to another. If the moon passed at every new moon exactly between the centres of the sun and earth, we should have a great eclipse of the sun at every new moon, and a total eclipse of the moon at every full moon, (See Fig. 3;) but the moon's orbit or path makes an angle with the plane of the ecliptic, (the plane of the ecliptic is described by a line drawn from the centre of the sun, passing through the centre of the earth and extended to the heavens,) of about 5⅓ degrees, consequently one half of the moon's orbit is above the ecliptic, and the other half is below it.

The two opposite points where the moon's orbit cuts the plane of the ecliptic, are called the moon's nodes; the nodes do not keep in the same position with respect to the earth and sun, but have a retrograde motion of about 19 degrees in a year. This causes the moon at new moon to be too high or too low, so that the moon's shadow passes above the north pole or below the south pole, hence there is no eclipse, and at full moon, the moon passes either above or below the earth's shadow. A total eclipse of the moon occurs when the whole of the moon is immersed in the earth's shadow, (See Fig. 3;) but we occasionally have a partial eclipse of the moon which is caused by the moon's being so high or so low as only to be partially immersed in the earth's shadow, (See Fig. 4.) The diameter of the sun and moon's discs is divided into twelve equal parts, called digits (See Fig. 6;) but by inspecting the diagram, it will be seen that when the sun is said to have six digits eclipsed, that only about one third of the disc of the sun is covered by the moon, although one half of the diameter of the sun is hidden from view. The sun and moon appear to be about the same size, but the apparent size of both is subject to some variation: when the earth is in that point of its orbit nearest the sun (January 1st,) the sun appears larger than at any other time during the year, and, when the moon is at the greatest distance from the earth, she appears the smallest. If an eclipse of the sun should take place exactly at this time, the shadow of the moon would terminate in a point before it reached the earth, and the moon would not appear large enough to cover the whole disc of the sun, but would produce what is called an annular eclipse, or the sun would appear like a luminous ring around the moon, (Sec Fig. 9;) but if the earth was at its greatest distance from the sun (July 1st) and the moon the nearest to the earth, then the moon would appear larger than the sun, and the shadow of the moon would touch the earth before it terminated in a point; this would produce a total and as great an eclipse of the sun as can take place, (See Fig. 3.) A total eclipse of the sun is visible only to a small portion of the earth at one and the same time, the shadow of the moon where it touches the earth would be only about 150 miles in diameter, consequently there would be only a space across the earth from west to east about 150 miles wide, in which it would appear total, but, a partial eclipse would be seen from a space more than 2,000 miles wide on each side of the umbra, or dark shadow. Those who lived north of the dark shadow would see the southern portion of the sun eclipsed, and those who lived south of it, would see the northern limb of the sun eclipsed.

Eclipses of the sun are more frequent than of the moon, because the sun's ecliptic limits are greater than the moon's, yet we have more visible eclipses of the moon than of the sun, because eclipses of the moon are visible from all parts of the earth where the moon is above the horizon, and are equally great to each of those parts; but eclipses of the sun are visible only to those places upon which the moon's shadow falls.

IF THE SUN WAS SMALLER THAN THE EARTH THE EARTH'S SHADOW WOULD INCREASE

FIG.1

IF THE SUN & EARTH WERE THE SAME, THE EARTH'S SHADOW WOULD BE CYLINDRICAL

FIG.2

FIG.3

ECLIPSE OF THE SUN

TOTAL ECLIPSE OF THE MOON

EARTH'S SHADOW 600,000 MILES LONG

FIG. 4

NEW MOON

FULL-MOON

PARTIAL ECLIPSE OF THE MOON

FIG. 5

THE MOON'S SHADOW PASSES ABOVE THE NORTH POLE THEREFORE NO ECLIPSE

THE MOON PASSES ABOVE THE EARTH'S SHADOW NO ECLIPSE

THE MOON'S SHADOW PASSES BELOW THE SOUTH POLE NO ECLIPSE

THE MOON PASSES BELOW THE EARTH'S SHADOW NO ECLIPSE

FIG.6

DIGITS ECLIPSED

1 2 3 4 5 6 7 8 9 10 11 12 11 10 9 8 7 6 5 4 3 2 1

MOON'S ASCENDING NODE

MOON'S PATH OR ORBIT

FIG.7

PARTIAL ECLIPSE OF THE SUN

MOON

FIG 8

TOTAL ECLIPSE OF THE SUN

MOON

FIG. 9

ANNULAR ECLIPSE OF THE SUN

MOON

LESSON XXXVII.

MOON'S NODES.

Question. WHAT are nodes?

Answer. They are two opposite points where the orbit of the moon, or any other planet intersects the plane of the earth's orbit or ecliptic.

Q. What angle does the moon's orbit make with the plane of the earth's orbit or ecliptic.

A. About $5\frac{1}{7}$ degrees. (5° 8′ 48″.)

Q. What part of the moon's orbit is above or north of the plane of the earth's orbit?

A. One half, the other half being below, or south of the earth's orbit?

Q. What is the ascending node?

A. It is that point where the moon passes the plane of the earth's orbit from south to north.

Q. What is the descending node?

A. It is that point where the moon passes the plane of the earth's orbit from north to south.

Q. Do the nodes change their position as regards a fixed point in the heavens?

A. They have a retrograde motion of about 19 degrees in a year.

Q. When is the moon in north latitude in the heavens?

A. When it is north of the earth's orbit or ecliptic.

Q. When is the moon in south latitude in the heavens?

A. When it is south of the earth's orbit or ecliptic.

Q. What is the greatest latitude of the moon?

A. $5\frac{1}{7}$ degrees north or south of the earth's orbit or ecliptic.

Q. What is the greatest declination of the moon, or its distance north or south of the equinoctial or equator?

A. About $28\frac{1}{2}$ degrees.

LESSON XXXVIII.

Q. How near one of the nodes must the moon be at new moon to cause an eclipse of the sun?

A. Within seventeen degrees. (16° 59″.)

Q. How near one of the nodes must the moon be at full moon to cause an eclipse of the moon?

A. About 12 degrees. (11° 25′ 4″.)

Q. If the moon is exactly in one of her nodes at new or full moon, what kind of an eclipse will it cause?

A. It will cause a great eclipse of the sun or moon.

Q. What is the extent of the solar ecliptic limit in which an eclipse of the sun can take place?

A. Thirty-four degrees, seventeen degrees on each side of either node.

Q. What is the extent of the lunar ecliptic limit in which an eclipse of the moon can take place?

A. Twenty-four degrees, twelve on each side of either node.

INFERIOR AND SUPERIOR CONJUNCTION.

Q. How many kinds of conjunction are there?

A. Two; inferior and superior.

Q. When is a planet in inferior conjunction with the sun?

A. When it is between the earth and sun.

CONJUNCTION.—Continued.

Q. What planets can be in inferior conjunction?

A. Mercury and Venus; also the moon.

Q. When are two planets in superior conjunction?

A. When they are on opposite sides of the sun.

Q. What planets can be in superior conjunction with the sun?

A. All the planets, except the earth and moon.

LESSON XXXIX.

INFERIOR AND SUPERIOR PLANETS.

Q. How are the primary planets divided?

A. They are divided into two classes, inferior and superior.

Q. Which are the inferior planets?

A. Mercury and Venus.

Q. Why are they called inferior planets?

A. Because their orbits are within the orbit of the earth.

Q. Which are the superior planets?

A. Mars, "*the Asteroids,*" Jupiter, Saturn, Herschel and Leverrier.

Q. Why are they called superior planets?

A. Because their orbits are greater than the orbit of the earth.

HELIOCENTRIC AND GEOCENTRIC LATITUDE AND LONGITUDE.

Q. What is the Heliocentric latitude and longitude of a planet?

A. It is its latitude and longitude, as seen from the sun. (See Diagram.)

Q. What is the Geocentric latitude and longitude of a planet?

A. It is its latitude and longitude as seen from the earth.

Q. Does a planet, seen from the earth, appear to have the same longitude as it would have if seen from the sun at the same time?

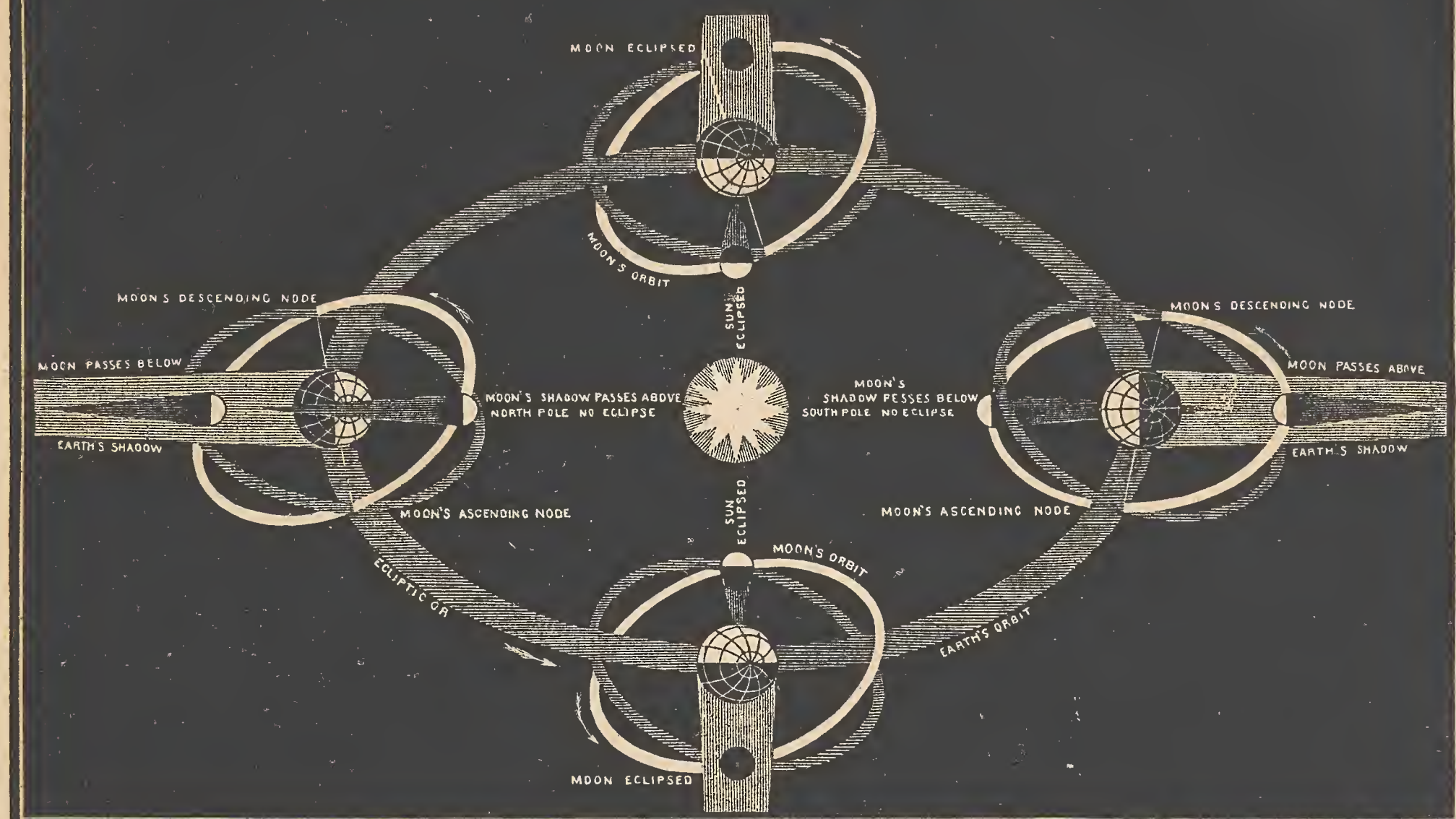
A. It does not, unless the earth is between the sun and planet.

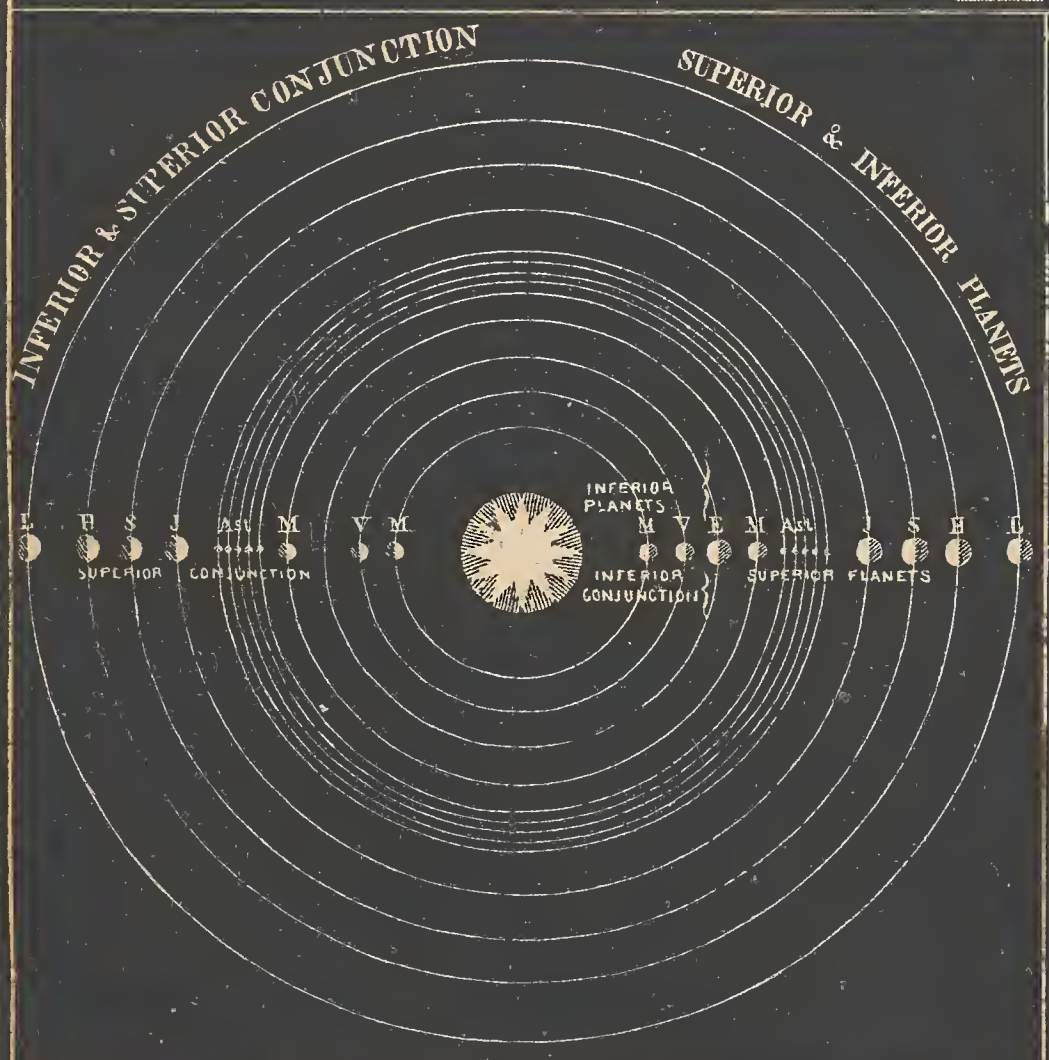
IT will be seen by inspecting the diagram upon the opposite page, that there are two small circles introduced into the diagram, the white circle which represents the moon's orbit, and the shaded circle which lies in the plane of the earth's orbit or ecliptic; this shaded circle is introduced into the diagram only to show the two points where the moon's orbit intersects the plane of the earth's orbit or ecliptic; these two points are called the moon's nodes; the point where the moon passes from the south to the north side, or above the earth's orbit, is called the ascending node; and the opposite point, or where the moon descends below the earth's orbit, is called the descending node; the line passing through the centre of the earth from one node to the other, is called the "*line of the nodes.*" It will be seen also that one half of the moon's orbit is above the plane of the earth's orbit, and the other half below it.

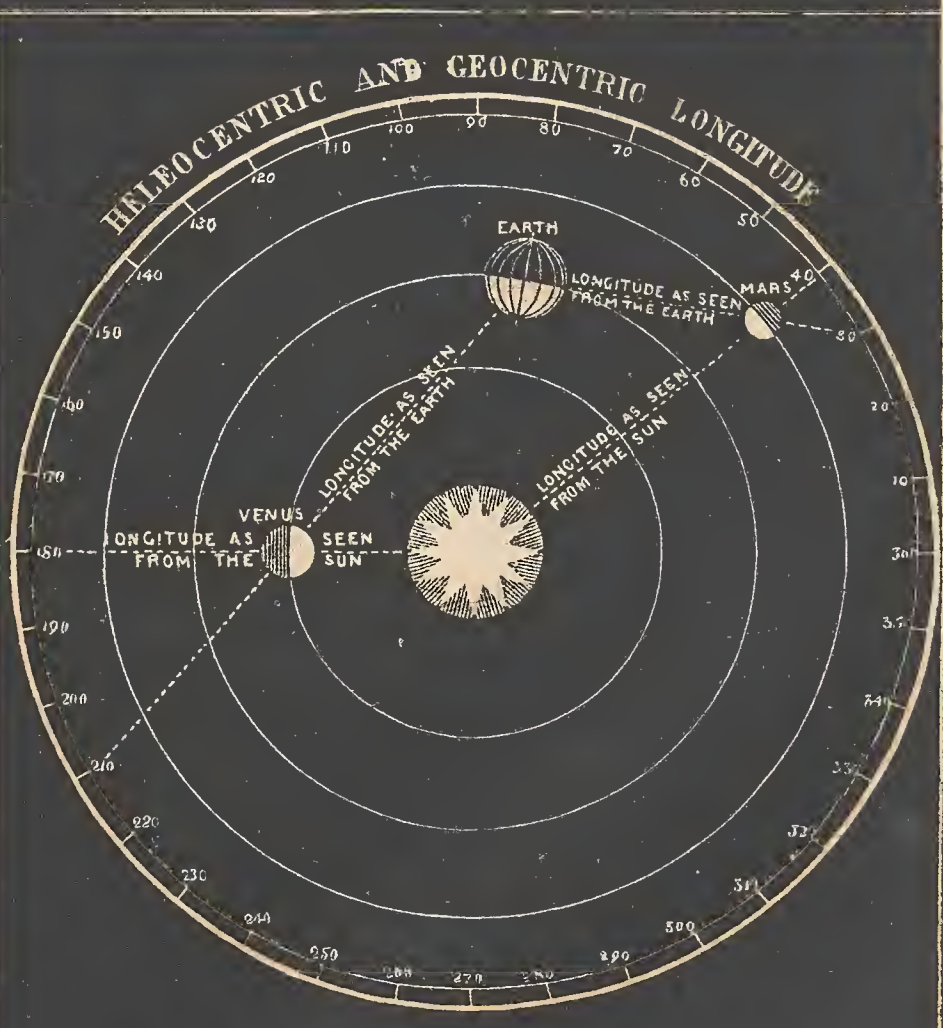
The planets *Mercury* and *Venus* are called inferior planets, because their orbits are within that of the earth, and of course nearer to the sun. The other primary planets, Mars, Asteroids, Jupiter, Herschel and Leverrier, are called superior planets for the same reason that their orbits are greater, or outside that of the earth.

It will be seen by inspecting the diagram upon the opposite page, that the planets, seen by two observers at the same time, one upon the sun and the other upon the earth, would not appear to be exactly in the same point of the heavens. The heliocentric longitude of a planet is where it would appear to be if seen from the sun, and the geocentric longitude of a planet is its longitude as seen from the earth.

MOONS NODES, ECLIPSES, &c.







LESSON XL.

GREATEST NUMBER OF ECLIPSES IN A YEAR.

Question. What is the greatest number of eclipses that can take place in a year?

Answer. Seven; five of the sun and two of the moon.

Q. What is the least number of eclipses that can take place in a year?

A. Two; both of the sun.

Q. What must be the position of the moon and her ascending node, on the first day of January, to cause seven eclipses in a year?

A. It must be new moon, and the moon must be within 17 degrees of her ascending node at the time.

Q. When would the second eclipse take place?

A. The second eclipse would be of the moon, January 15th, at her descending node.

Q. When would the third eclipse take place?

A. The third eclipse would be of the sun, January 29th, at the moon's ascending node.

Q. When the fourth eclipse?

A. The fourth eclipse would be of the sun, June 26th, at the moon's descending node.

Q. When the fifth eclipse?

A. The fifth eclipse would be of the moon, July 11th, at her ascending node.

Q. When the sixth eclipse?

A. The sixth eclipse would be of the sun, July 25th, at the moon's descending node.

Q. When the seventh and last eclipse?

A. The seventh eclipse would be of the sun, December 20th, at the moon's ascending node.

Q. Why are there no eclipses in this case from January 29th to June 26th?

A. Because the moon is so high at new moon that its shadow passes above the north pole, and at full moon, the moon passes below the earth's shadow.

Q. Why are there no eclipses in this case from July 25th to December 20th?

A. Because the moon is so low at new moon, that its shadow passes below the south pole, and at full moon, the moon passes above the earth's shadow.

Q. What must be the position of the moon and her ascending node, on the 1st day of January, to cause only two eclipses during the year?

A. It must be new moon, and the moon must be in or very near her ascending node.

Q. How often are there seven, or only two eclipses in a year?

A. Not oftener than once in a hundred years.

Q. What is the most common number of eclipses in a year?

A. Four.

Greatest Number of Eclipses in a Year.

When the moon is within 17 degrees of either node at new moon, it will cause an eclipse of the sun, and when the moon is within 12 degrees of either node at full moon, the moon will then be more or less eclipsed. If the line of the nodes were carried parallel to itself around the sun, there would be just half a year from the time of one node passing the sun, to the other's coming around to the sun; but as the nodes have a retrograde motion of about nineteen degrees in a year, it is only 177 days from the conjunction of one node to the conjunction of the other, therefore, in whatever time of the year we have eclipses of the sun or moon at either node, we may be sure that in 177 days, we shall have eclipses about the other node. If we suppose the moon at new moon to be 17 degrees from her ascending node on the first day of January, there would be a small eclipse of the sun, and at the next full moon, January 15th, there would be a total eclipse of the moon; as the moon would be only about 2 degrees from the descending node; at the next new moon, January 29th, the moon would then be about 12 degrees upon the other side of the ascending node, which would cause another small eclipse of the sun,—hence we would have two small eclipses of the sun at the ascending node, and one great eclipse of the moon at the descending node, from January 1st to January 29th. (See Diagram.) At every subsequent new moon, the moon would be so high that the shadow would pass above the north pole, and at every full moon, the moon would pass below the earth's shadow, until June 26th, when the moon's descending node would come around to the sun, (see Diagram;) at this time the moon would be about 7 degrees from her descending node; this would cause another eclipse of the sun. At the next full moon, July 11th, there would be another total eclipse of the moon; again, at the next new moon, July 25th, the moon would still be within 17 degrees of her descending node, which would produce another small eclipse of the sun.

From July 25th, there would be no eclipses of the sun or moon, as at every subsequent new moon, the moon would be so low that the shadow of the moon would pass below the south pole, and at every full moon the moon would pass above the earth's shadow, until December 20th, when the ascending node would come around again to the sun, and at the 12th new moon in the year, the moon would again be within 17 degrees of her ascending node; we would, therefore, have another small eclipse of the sun, which would be the seventh and last eclipse during the year. It will be seen from the above, that we should have five eclipses of the sun, and two total eclipses of the moon, during the year, which is the greatest number that can possibly take place in a year. Seven eclipses in a year do not occur twice in a hundred years, although perhaps we may have seven eclipses in one year's time, for several times during a century. To have seven eclipses during the same year, it is necessary that the moon and nodes be in a particular position on the first day of January.

After the sun, moon and nodes have been once in a line of conjunction; they return nearly to the same position again in 223 lunations or 18 years 11 days 7 hours 43 minutes 20 seconds, when four leap years are included, or one day less, when five leap years are included; consequently, if to the mean time of any eclipse of the sun or moon, we add 18 years 11 days 7 hours 43 minutes 20 seconds, we shall have the mean time of the return of the same eclipse for a long period of time. This period was first discovered by the Chaldeans, by a long series of observations, extending through many centuries, and by it they were able to foretell, with considerable exactness, the appearance of an eclipse, varying at most but a few hours. Every eclipse within this period of 18 years, belongs to a separate series of eclipses, that is, there is but one eclipse during the 18 years, which belongs to the same series. If any series of eclipses commence at the ascending node, the shadow of the moon just touches the earth at the north pole; at the next return in 18 years, the shadow will pass across the earth a little more to the south, and at each return, the shadow will continue to pass more to the south until it will have appeared about 77 times, which will take about 1,388 years, when it will pass off the earth at the south pole, and at the expiration of 12,492 years, the same eclipses will commence again to go through a similar course. Those eclipses of the sun which come in at the descending node, the shadow of the moon first touches the earth at the south pole, and at each return passes more to the north, and finally leaves the earth at the north pole, after having appeared the usual number of times. The velocity of the moon's shadow across the earth in an eclipse of the sun is about 1,850 miles an hour, or about four times the velocity of a cannon ball. The moon when totally eclipsed, is generally visible if it is above the horizon, and the sky is clear: it generally appears of a faint dusky red, or copper color, this is caused by the rays of the sun, which pass through the atmosphere of the earth, and are refracted or bent inward, so that some of the rays fall upon the moon and render it visible.

GREATEST NUMBER OF ECLIPSES IN ONE YEAR

THIS CIRCLE WHICH IS IN THE SAME PLANE OF THE EARTHS ORBIT AND INTERSECTS THE MOONS ORBIT AT TWO OPPOSITE POINTS , CALLED NODES IS INTRODUCED INTO THE DIAGRAM TO SHOW THE POSITION OF THE NODES AT EACH NEW AND FULL MOON DURING THE YEAR

MOON PASSES THROUGH THE EARTH'S SHADOW MOON'S DESCENDING NODE

2ND AN ECLIPSE OF THE MOON JANY 15

MOON'S ORBIT

MOON PASSES BELOW THE EARTH'S SHADOW

MOON PASSES BELOW THE EARTH'S SHADOW

MOON'S ASCENDING NODE

MOON PASSES BELOW THE EARTH'S SHADOW

MOON PASSES ABOVE THE EARTH'S SHADOW

3RD AN ECLIPSE OF THE SUN JAN 30TH

1ST AN ECLIPSE OF THE SUN JAY 11TH

7TH AN ECLIPSE OF THE SUN DEC 20TH

MOON'S SHADOW PASSES ABOVE THE NORTH POLE

MOON'S SHADOW PASSES BELOW THE SOUTH POLE

MOON PASSES BELOW THE EARTH'S SHADOW

MOON PASSES ABOVE THE EARTHS SHADOW

MOON'S SHADOW PASSES ABOVE THE NORTH POLE

MOON'S SHADOW PASSES BELOW THE SOUTH POLE

MOON'S SHADOW PASSES ABOVE THE NORTH POLE

6TH AN ECLIPSE OF THE SUN JULY 25TH

MOON PASSES BELOW THE EARTH'S SHADOW

MOON PASSES ABOVE THE EARTH'S SHADOW

4TH AN ECLIPSE OF THE SUN JUNE 26TH

MOON'S ORBIT

MOON PASSES BELOW THE EARTH'S SHADOW

MOON PASSES ABOVE THE EARTHS SHADOW

MOON PASSES THROUGH THE EARTHS SHADOW

5TH AN ECLIPSE OF THE MOON JULY 11TH

EXPLANATIONS

MOON — MOON'S SHADOW

A MOON'S ASCENDING NODE
D MOON'S DECENDING NODE
E EARTH
S EARTH'S SHADOW
O EARTH'S ORBIT, AROUND THE SUN

LESSON XLI.

TIDES.

Question. What motion have the earth and moon, besides revolving around the sun?

Answer. They revolve around their common centre of gravity?

Q. In what part of a straight line joining their centres, is the centre of gravity situated?

A. About 3,200 miles from the centre of the earth.

Q. What effect has the centrifugal force upon the water on the opposite side of the earth from the moon?

A. It causes it to recede from the centre of gravity, and to rise on that part of the earth.

Q. What effect has this upon the shape of the earth?

A. Its diameter is lengthened in the line of the moon's attraction, and shortened at right angles to it.

Q. What tends to increase this oval shape of the earth?

A. The inequality of the attraction of the moon at the different sides of the earth.

[The water upon the side of the earth nearest to the moon, is more attracted than the centre of the earth; the water upon the opposite side is less attracted.]

Q. What effect does the turning of the earth, from west to east on its axis, produce?

A. It causes these elevations, or tide waves, to pass from east to west around the earth.

Q. What is tide?

A. It is the rising and falling of the waters of the ocean.

Q. How are the tides divided with respect to the rising and falling of the water?

A. Into flood and ebb.

Q. What is flood tide?

A. It is the rising of the water.

Q. What term designates the greatest elevation of the flood tide?

A. High water.

Q. What is ebb tide?

A. It is the falling of the water.

Q. How often do flood and ebb tide occur?

A. Twice in about 25 hours.

Q. Do the tides rise at the same hour every day?

A. They rise about an hour later each day.

Q. Why do the tides rise later?

A. Because the moon passes the meridian about an hour later each day.

Q. What causes the moon to be later at the meridian?

A. It is caused by its revolving monthly around the earth from west to east.

Q. Does the attraction of the sun produce an effect similar to that of the moon?

A. It tends to raise a tide two fifths as high.

Q. When the sun and moon are on the same or opposite sides of the earth, what is the effect of their attractive forces?

A. They raise a tide equal to the sum of their separate tides.

Q. When they are in quadrature, what is the effect of their counteracting forces?

A. They raise a tide equal to the difference of their tides.

LESSON XLII.

Q. How are tides divided with respect to their comparative height?

A. Into spring and neap.

Q. What is spring tide?

A. It is the greatest flood and ebb tide.

Q. What is neap tide?

A. It is the least flood and ebb tide.

Q. What proportion do these tides bear to each other?

A. The neap tide is about three sevenths as great as the spring tide.

Q. When do spring tides occur?

A. Twice in each lunar month, at new and full moon.

Q. When do neap tides occur?

A. Twice in each lunar month at the quarters.

Q. What effect have the continents upon the tide waves when passing round the earth?

A. They subject them to great irregularities.

Q. Which side of the continents have the highest tides, the eastern or the western?

A. The eastern side.

Q. Does the water remain permanently higher on the east than on the west side of the continents?

A. The gulf of Mexico is 20 feet higher than the Pacific ocean, and the Red sea is 30 feet higher than the Mediterranean.

Q. Where the tide wave is least obstructed, as in the Pacific ocean, how much behind the moon is it?

A. It is two or three hours behind it.

Q. How long after the moon passes the meridian, is it high water at New York?

A. About $8\frac{1}{2}$ hours.

Q. If the earth were uniformly covered with water, how high would the tide rise?

A. Not more than two or three feet. (The tide at the small islands in the Pacific ocean is usually less.)

Q. What produces the greatest effect in causing high tides?

A. The shape of the land, and the position of the shores.

Q. Where are the highest tides in the world?

A. In the bay of Fundy.

Q. What, besides the position of the shores, tends to raise a high tide at this place?

A. The meeting of the tide wave from the North Atlantic ocean, with the main one from the South Atlantic.

Q. How high are the average spring tides at Cumberland near the head of the bay of Fundy?

A. About 71 feet.

Q. How high are they at Boston?

A. About 11 feet.

Q. At New York?

A. About 5 feet.

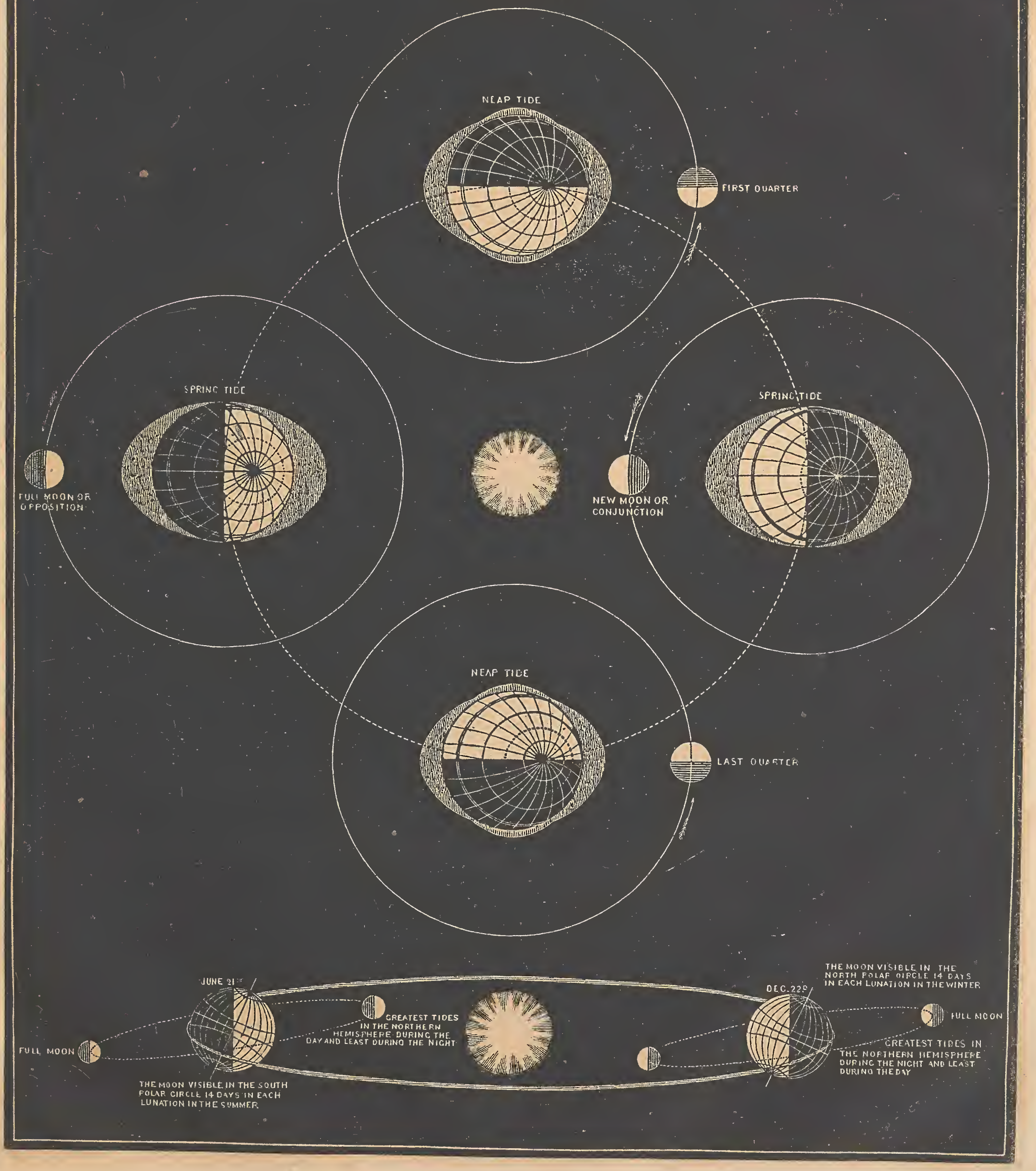
Q. At Charleston, South Carolina.

A. About 6 feet.

Q. When do we have the highest tides in the northern hemisphere?

A. At new moon in the summer, and at full moon in the winter. (See Diagram.)

TIDES


NEAP TIDE
FIRST QUARTER
SPRING TIDE
FULL MOON OR OPPOSITION
NEW MOON OR CONJUNCTION
SPRING TIDE
NEAP TIDE
LAST QUARTER
JUNE 21st
GREATEST TIDES IN THE NORTHERN HEMISPHERE DURING THE DAY AND LEAST DURING THE NIGHT
FULL MOON
THE MOON VISIBLE IN THE SOUTH POLAR CIRCLE 14 DAYS IN EACH LUNATION IN THE SUMMER
DEC. 22nd
THE MOON VISIBLE IN THE NORTH POLAR CIRCLE 14 DAYS IN EACH LUNATION IN THE WINTER
FULL MOON
GREATEST TIDES IN THE NORTHERN HEMISPHERE DURING THE NIGHT AND LEAST DURING THE DAY

LESSON XLIII.

ORBITS OF THE PLANETS AND COMETS.

Question. WHAT is the orbit of a primary planet?

Answer. It is the path in which it revolves around the sun.

Q. What is the orbit of a secondary planet?

A. It is the path in which it revolves around its primary.

Q. What is the form of the orbits of all the planets?

A. Elliptical, or longer one way than the other.

Q. Are all the orbits elliptical in the same proportion?

A. They are not; some are more elongated than others.

Q. What is the position of the orbits of all the planets?

A. They extend from west to east in the heavens.

Q. Do the planes of their orbits, intersect the ecliptic or orbit of the earth?

A. They do, at small angles. (See Diagram.)

Q. Do they all intersect the plane of the earth's orbit at one point, as represented in the diagram?

A. They do not; but intersect it at different points.

Q. Through what point does the plane of the orbit, of every primary planet and comet in the solar system, pass?

A. Through the centre of the sun.

Q. Are the planets at nearly the same distance from the sun?

A. They are not, but at very different distances.

Q. Are their orbits all contained within the zodiac?

A. They are, except those of a part of the asteroids.

Q. How wide is the zodiac?

A. Sixteen degrees wide: eight degrees on each side of the ecliptic.

Q. Do all the planets revolve around the sun in the same direction?

A. They do; from west to east.

Q. Do they all move with the same velocity?

A. The velocity decreases as the distance from the sun increases.

Q. Which planet moves in its orbit with the greatest velocity?

A. Mercury.

Q. Which moves with the least?

A. Leverrier, or Neptune.

Q. When does a planet have north latitude?

A. When it is above, or north of the earth's orbit.

Q. When does a planet have south latitude?

A. When it is below, or south of the earth's orbit.

LESSON XLIV.

COMETS.

Question. WHAT are comets?

Answer. They are bodies which revolve around the sun in very elongated orbits.

Q. How are comets usually distinguished from the planets?

A. By a luminous train or tail, on the opposite side from the sun.

Q. Is this luminous train always on the opposite side from the sun?

A. Not always; a few have been observed to have a different direction.

Q. Do comets ever appear without a luminous train?

A. Some are entirely destitute of any such appendage.

Q. What is the number of comets?

A. The number is not known; about 500 have been seen at different times.

Q. Are comets solid bodies like the planets?

A. They generally are not; although some have been observed to have a dense nucleus, or head

Q. What is the nature of comets?

A. They are supposed to be gaseous matter, in the form of smoke, fog, or clouds.

Q. Do comets shine by their own, or by reflected light?

A. They shine by reflected light.

Q. Do they all, like the planets, revolve in the same direction around the sun?

A. They do not; they revolve in different directions.

Q. Are all their orbits within the zodiac?

A. They are not; their orbits are in all directions in the heavens.

Q. How do many of them move when first seen?

A. They appear to move in almost a direct line towards the sun.

Q. Does their velocity increase as they aproach the sun?

A. It does; and when near it, they move with immense velocity.

Q. How fast has a comet been known to move?

A. 880,000 miles an hour.

Comets.

COMETS were anciently viewed by mankind with astonishment and fear, as being forerunners of dreadful calamities, such as war, famine, or pestilence. Many ancient philosophers considered them as only meteors in the atmosphere. Tycho Brahe was the first who showed that they belonged to the planetary system, and revolved around the sun. The orbits of all the comets are very elliptical, so that they approach the sun almost in a direct line, and after being involved in the light of the sun for a short time, depart from our solar system in nearly the same direction, in which they approached, and remain for years, or even centuries, beyond the limit of the best telescopes.

Very little is known of the *physical nature of comets;* the smaller comets, such as are visible only with telescopes, generally have no appearance of a tail, and appear like round or somewhat oval, vaporous masses, more dense towards the centre; yet they have no distinct nucleus or solid body. Stars of the smallest magnitude are seen through the most dense parts of these bodies. It is very probable that the luminous part of a comet is something of the nature of smoke, fog, or other gaseous matter. Halley's comet, which appeared in 1456, with a tail 60 degrees in length, and spread out like a fan, has appeared periodically every 77th year, viz: 1682, 1759, and in 1836; but it has exhibited no tail, or luminous appendage, since 1456. The comet which appeared 371 years before Christ, is said to have covered a third part of the visible heavens. A remarkable comet made its appearance 43 years before Christ, and was so bright as to be visible in the day time; it was supposed, by the superstitious, to be the ghost of *Cæsar*, who had just been assassinated. The following are some of the most remarkable comets:—

Comet of	1680,	length of the tail	123,000,000	miles.
Do.	1744,	"	35,000,000	"
Do.	1769,	"	48,000,000	"
Do.	1811,	"	130,000,000	"
Do.	1843,	"	130,000,000	"

ORBITS OF THE PLANETS

DRAGON
LESSER BEAR
HARP
CAMELEOPARD
HERCULES
NORTH STAR
LYNX
SHIELD
BULL
AXIS OF THE ECLIPTIC
AXIS OF THE EQUINOCTIAL
WAGGONER
COMET
EQUINOCTIAL 23½°
JUNO 13° 3′ 28″
VESTA 7° 8′ 46″
VENUS 3° 23′ 0″
MARS 1° 51′ 0″
HERSCHEL 0° 46′ 37″
EARTH
JUPITER 1° 18′ 51″
SATURN 2° 30′ 35″
MERCURY 7° 0′ 9″
CERES 10° 37′ 34″
COMET
ARCHER
TWINS
CROWN
ORION
PALLAS 34° 37′ 8″
TELESCOPE
HARE
PEACOCK
GREAT DOG
OCTANT
NOAHS DOVE
EASEL
SWORD FISH

LESSON XLV.

ATMOSPHERE.

Question. WHAT is air?

Answer. It is an elastic, invisible fluid, which surrounds the earth.

Q. Of what, besides air, is the atmosphere composed?

A. Of vapor, carbonic acid, and other gases.

Q. Is the atmosphere of the same density as we ascend from the earth?

A. It grows thinner or less dense.

Q. What is the estimated hight of the atmosphere?

A. About forty-five miles.

Q. What is the pressure of the atmosphere upon the earth?

A. Nearly fifteen pounds to the square inch. (14.6.)

Q. What is the weight of air compared with water?

A. It is 816 times lighter than water.

Q. The pressure of the atmosphere is equal to a column of water, of what height?

A. Thirty-three feet.

Q. Of what is air composed?

A. Of oxygen and nitrogen gases.

Q. In what proportions?

A. Twenty parts of oxygen to eighty parts of nitrogen.

LESSON XLVI.

REFRACTION.

Question. WHAT is refraction?

Answer. It is the deviation of the rays of light from a straight line.

Q. What is astronomical refraction?

A. It is the deviation of the rays of light in their passage through the atmosphere.

Q. What is the cause of this refraction?

A. It is caused by the increase of the density of the atmosphere towards the earth.

Q. In what part of the heavens is the light of a body most refracted?

A. In the horizon.

Q. What effect does this refraction have upon the sun at its rising and setting?

A. It makes the sun appear above the horizon when it is actually below it. (See Diagram.)

Q. Does this affect the length of the day?

A. It makes the day from six to ten minutes longer, from sun rise to sun set.

Q. Is the light of a body refracted when it is in the zenith?

A. It is not. (See Diagram.)

Q. What is twilight?

A. It is that faint light, seen before the sun rises and after it sets.

Q. What is the cause of twilight?

A. It is caused by the atmosphere's reflecting the light of the sun.

Q. Twilight ceases when the sun is, how far below the horizon?

A. Eighteen degrees.

LESSON XLVII.

PARALLAX.

Question. WHAT is parallax?

Answer. It is the difference between the apparent and true place of a heavenly body.

Q. What is the apparent place of a planet?

A. It is the place where it appears to be when seen from the surface of the earth.

Q. What is the true place of a planet?

A. It is the place where it would appear to be if seen from the centre of the earth, or centre of motion.

Q. Where is the parallax of a heavenly body the greatest?

A. At the horizon, and decreases to the zenith.

Q. How are parallaxes divided?

A. They are divided into two kinds, diurnal and annual parallax.

Q. What is diurnal parallax?

A. It is the apparent difference in the situation of a heavenly body when seen in the zenith and horizon of two places at the same time. (See parallax of Mars and Moon.)

Q. What is annual parallax?

A. It is the apparent difference in the situation of a star as seen from the earth in opposite points of its orbit.

Q. Have the stars been observed to have any sensible parallax?

A. A few have been observed to have a small parallax of a part of a second. (NOTE.—No parallax has been discovered in more than 30 or 40 of them.)

Q. What is the cause of their having no appreciable parallax?

A. Because they are at such an immense distance from us.

Q. If the earth's orbit were a solid ring, how large would it appear when viewed from the nearest fixed star?

A. No larger than a lady's finger ring.

LESSON XLVIII.

LIGHT AND HEAT.

Q. What bodies produce light?

A. Luminous bodies.

Q. Is light a substance thrown off from a luminous body, or is it caused by a vibratory motion?

A. It is probably caused by the undulations of an extremely subtle fluid.

Q. In what direction are the rays of light thrown off from a luminous body?

A. In straight lines, and in all directions.

Q. With what velocity does light move?

A. About 192 thousand miles a second. (192,500.)

Q. How was this amazing velocity ascertained?

A. By observing the eclipses of Jupiter's moons.

Q. In what proportion do the light and heat of the planets increase or decrease?

A. In inverse proportion to the squares of their distances from the sun.

Q. Which planet has the most light and heat, and which the least?

A. Mercury has the most, and Leverrier the least.

Q. If a board a foot square be placed one foot from a lighted candle, how many feet square would the shadow be upon the wall, nine feet from the candle?

A. Nine feet square, or eighty-one square feet.

Q. What amount of light and heat would fall upon the one foot and upon the 81 feet?

A. The same amount of light and heat would fall upon each.

REFRACTION, PARALLAX, LIGHT & HEAT

THE REFRACTION DECREASES FROM THE HORIZON TO THE ZENITH

THE REFRACTION INCREASES FROM THE ZENITH TO THE HORIZON

NOON

A

THE SUN APPEARS TO BE AT A

B

THE SUN APPEARS TO BE AT B

MORNING.
THE SUN APPEARS ABOVE THE VISIBLE HORIZON WHEN IT IS ACTUALLY BELOW IT.

EVENING.
THE SUN APPEARS ABOVE THE VISIBLE HORIZON WHEN IT IS ACTUALLY BELOW IT.

PARALLAX

IT WOULD APPEAR AT A

APPEAR AT B

MARS

ATMOSPHERE WHICH SURROUNDS THE EARTH

WHEN SEEN IN THE HORIZON IT WOULD

WHEN SEEN ON THE MERIDIAN IT APPEARS

MOON APPEARS AT THE

ON THE MERIDIAN

IN THE HORIZON

MOON

HORIZONTAL PARALLAX OF THE SUN IS VERY SMALL

EARTH

SQUARE OF 1

1 2 3 4 5 6 7 8 9

THE LIGHT AND HEAT OF THE PLANETS INCREASE OR DECREASE IN PROPORTION TO THE SQUARE OF THEIR DISTANCES FROM THE SUN.

EARTH'S ORBIT

FIXED STAR

IF THE EARTH'S ORBIT WAS A SOLID RING IT WOULD APPEAR NO LARGER THAN A LADY'S FINGER RING, WHEN SEEN FROM THE FIXED STARS

LESSON XLIX.

TERRESTRIAL AND CELESTIAL GLOBES.

Question. WHAT is a globe?

Answer. A globe is a round body or sphere.

Q. How many kinds of globes are there used in astronomy?

A. Two; terrestrial and celestial globes.

Q. What does the terrestrial globe represent?

A. It represents the earth.

Q. What are drawn upon the surface of the terrestrial globe?

A. Continents, islands, mountains, oceans, seas, rivers, republics, kingdoms, empires, &c.

Q. What does the celestial globe represent?

A. It represents the heavens as seen from the earth.

Q. What are usually drawn on the celestial globe?

A. The constellations or stars, galaxy or milky way, and the figures of various animals and objects from which the constellations are named.

Q. What is a constellation?

A. It is a group of stars, to which is applied the name of some animal or object.

Q. What is the number of constellations?

A. Ninety-three.

Q. In viewing the terrestrial globe, where is the observer supposed to be placed?

A. On its surface.

Q. In viewing the celestial globe, where must the observer suppose himself to be placed?

A. In the centre, looking towards the heavens. (Inside looking out.)

Q. What is the galaxy or milky way?

A. It is a luminous belt forming a complete circle in the heavens.

Q. Of what is the galaxy or milky way composed?

A. It is a vast number of stars, so far distant from us, and situated so nearly in the same direction, as to appear like a thin cloud.

Q. What is the position of the milky way in the heavens?

A. It extends from northeast to southwest through the whole circumference of the heavens.

Q. What are the celestial poles, or poles of the heavens?

A. They are the points where the earth's axis, if extended, would meet the heavens.

LESSON L.

Question. WHAT does the plane of the equator form, when extended to the heavens?

Answer. The equinoctial or celestial equator.

Q. At what angle do the ecliptic and equinoctial intersect each other?

A. At an angle of $23\frac{1}{2}$ degrees. (23° 28′)

Q. What does the plane of a meridian form when extended to the heavens?

A. A celestial meridian or circle of declination.

Q. What are measured on celestial meridians?

A. Declination and polar distance.

Q. What is the declination of a heavenly body?

A. It is its distance from the equinoctial, north or south.

Q. To what are the declination and polar distance always equal?

A. They are equal to 90 degrees, or a quarter of a circle.

Q. What is the right ascension of a heavenly body?

A. It is its distance east of the first point of Aries measured on the equinoctial.

Q. What angle expresses the right ascension?

A. The angle between the meridian passing through the body, and the one passing through the first point of Aries.

Q. How far is right ascension reckoned?

A. 360 degrees, or quite round the heavens.

Q. What are circles of latitude on the celestial globe?

A. They are great circles which pass through the poles of the ecliptic, and cut its plane at right angles.

Q. What is the latitude of a heavenly body?

A. It is its distance north or south of the ecliptic, measured on a circle of celestial latitude.

Q. What is the longitude of a heavenly body?

A. It is its distance east of the first point of Aries, measured on the ecliptic.

Q. What angle expresses the longitude?

A. The angle between the circle of latitude passing through the body, and the one passing through the first point of Aries.

Q. Where is this angle formed?

A. At the poles of the ecliptic, where the circles of latitude intersect each other.

Q. How far is celestial longitude reckoned?

A. It is reckoned 360 degrees.

LESSON LI.

Question. WHAT is a vertical circle?

Answer. It is a great circle in the heavens, passing through the zenith and nadir, and cutting the horizon at right angles.

Q. What vertical circle is the meridian?

A. It is that vertical circle which passes through the north and south points of the horizon.

Q. Which is the prime vertical?

A. The vertical circle which passes through the east and west points of the horizon.

Q. What are measured on the vertical circles?

A. Altitude and zenith distance.

Q. What is the zenith distance of a heavenly body?

A. It is its distance from the zenith.

Q. To what are the altitude and zenith distance always equal?

A. They are equal to 90 degrees.

Q. What is the azimuth of a heavenly body?

A. It is its distance east or west of the meridian.

Q. What angle expresses the azimuth?

A. The angle between the meridian and the vertical circle passing through the body.

Q. What is the amplitude of a heavenly body?

A. It is its distance north or south of the prime vertical.

Q. What angle expresses the amplitude?

A. The angle between the prime vertical, and the vertical circle passing through the body.

Q. Where are the angles expressing azimuth and amplitude formed?

A. At the zenith where the vertical circles intersect each other.

Q. On what circle are these angles measured?

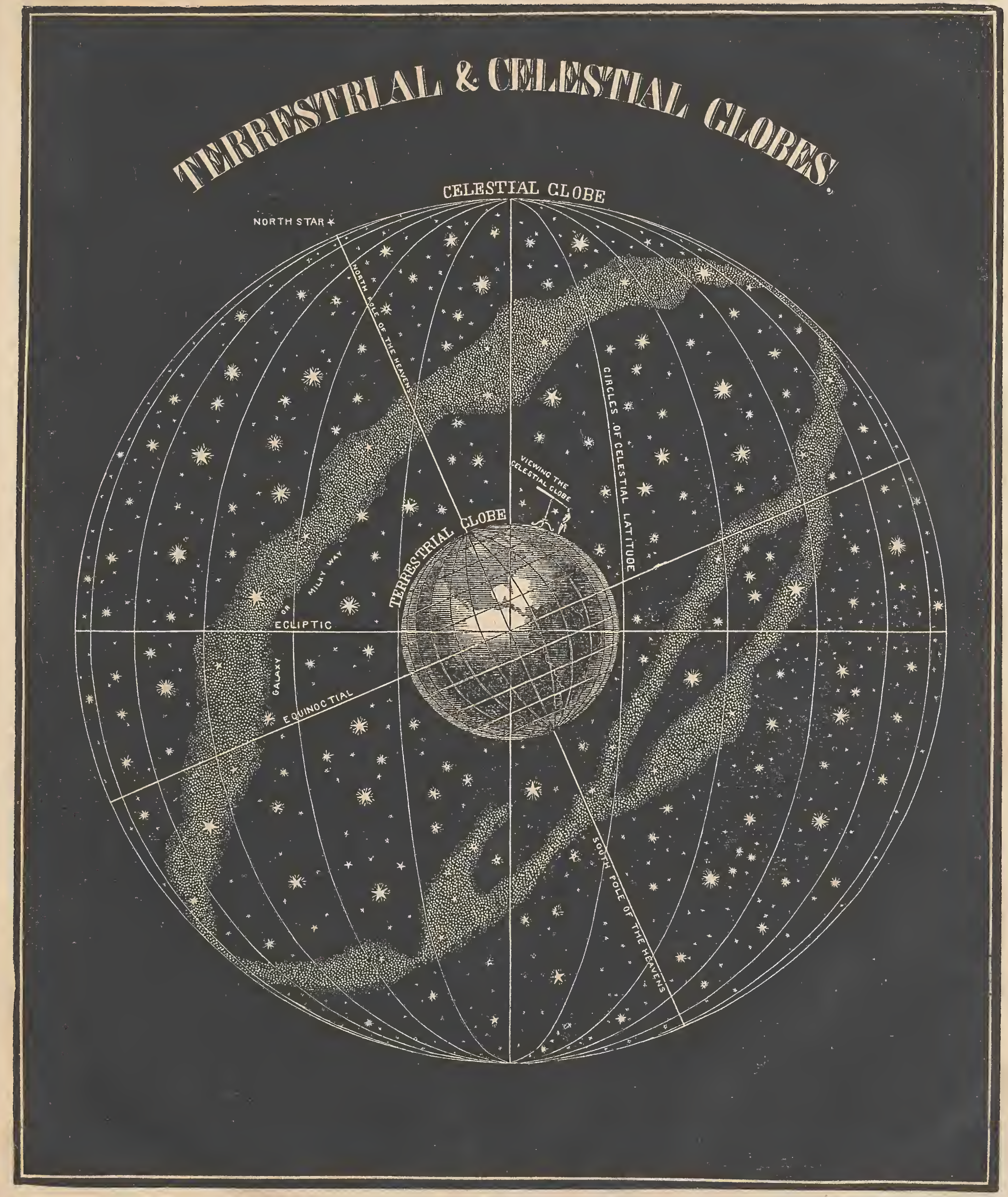
A. On the horizon.

Q. To what are azimuth and amplitude always equal?

A. They are equal to 90 degrees.

[The diagram can be used to illustrate azimuth, amplitude, altitude, and zenith distance, by supposing the ecliptic to represent the celestial horizon, and the circles of celestial latitude to represent vertical circles.]

TERRESTRIAL & CELESTIAL GLOBES.



LESSON LII.

THE FIXED STARS.

Question. WHAT are those stars called which always appear to be in the same situation with respect to each other?

Answer. They are called the fixed stars.

Q. What are the fixed stars supposed to be?

A. They are supposed to be suns like our own, with planets revolving around them.

Q. Are the stars luminous or opake bodies?

A. They are luminous bodies. (Astronomers have no doubt on this point.)

Q. Are all the stars of the same magnitude as the sun?

A. They are not; some are larger, and others no doubt smaller than the sun. (NOTE 1.)

["From the orbital motion of the double star 61 Cygni, compared with its distance, Bessel has concluded that the conjoint mass of its two individuals is 'neither much more nor much less than half the mass of our sun.' From the photometric experiments of Wollaston, on α (Alpha) Lyræ, compared with what we know of its distance, its actual emission of light may be gathered to be not less than 5½ times that of the sun. Sirius, which is nine times as bright as α Lyræ, and whose parallax is insensible, cannot, therefore, be estimated at less than 100 suns." *Edinburgh Review.*]

Q. What is the distance of the nearest fixed star, α (Alpha) Centauri?

A. It is so far distant that a cannon ball going 500 miles an hour, would take four millions of years to reach it.

Q. What is the number of stars whose distance is imperfectly known to us?

A. About 35; seven of which have their distances determined with considerable certainty.

Q. Do all the stars remain of the same brilliancy?

A. They do not; some exhibit a periodical change in their light.

Q. What is supposed to be the cause of this change in their light?

A. The revolution on their axes is supposed to present, alternately to us, sides of different brightness.

Q. What are those stars called which appear to be surrounded by a thin atmosphere?

A. Nebulous stars.

Q. Do stars ever disappear, or new ones become visible?

A. Thirteen stars have disappeared, and ten new ones become visible, during the last century. (Note 2.)

Q. What is supposed to be the cause of their disappearance?

A. They have probably ceased to be luminous.

Q. How do astronomers account for the appearance of new stars?

A. Opake bodies may have become luminous, or new suns may have been created.

LESSON LIII.

Question. WHAT do the milky way and the single stars that are visible to the naked eye, including our sun, constitute?

Answer. They constitute an immense cluster, or firmament, entirely distinct from the other clusters or nebulæ of the heavens. (FIG. 1.)

Q. What is the shape of this great cluster or firmament?

A. It has the form of a wheel or burning-glass.

[The stars extend much farther in the direction of the plane of the milky way, than they do at right angles to it. SEE DIAGRAM.]

Q. What is the number of stars in our cluster?

A. They have been variously estimated from 10 to 100 millions.

Q. By what term do some astronomers designate our cluster or firmament?

A. They call it the universe. (NOTE 3.)

Q. Do the fixed stars have any apparent motion?

A. They do, but it is so slight as not to be easily detected.

Q. Around what, are all the stars in our cluster, including the sun, supposed to revolve?

A. Around the common centre of gravity of the cluster. [FIG. 1.)

Q. What group of stars is thought to be near the centre of the cluster?

A. The Pleiades, or seven stars. (Dr. Maedler.)

Q. In what part of the cluster is the solar system situated?

A. It is comparatively near the centre.

Q. How far from us is the centre of the cluster supposed to be?

A. About 150 times the distance of the nearest fixed star.

[Light is about 8 minutes in coming from the sun; about 3½ years in coming from the nearest fixed star, α Centauri; about 500 years in coming from the supposed centre of the cluster; and about 5,000 years in coming from the most remote stars in the cluster.]

Q. How long will it take the sun to revolve around this centre of gravity?

A. About twelve millions of years.

Q. What other motion have some of the stars, besides around the centre of the cluster?

A. Multiple stars, consisting of two or more, revolve likewise around their common centre of gravity.

Q. What is the number of these multiple stars?

A. About 6,000 have been observed.

Q. Do these stars appear double to the naked eye?

A. They do not; the most, require a good telescope to separate them.

Q. When multiple stars consist of but two, what are they usually called?

A. Double stars, or binary systems.

NOTE 1.—Astronomers, until recently, considered all the stars to be of about the same magnitude, and probably as large as the sun; and that the stars of the first magnitude owed their brilliancy to their being nearer to us; but it has been found that the brightest star (SIRIUS) in the whole heavens, and which was considered to be the nearest fixed star, is at a much greater distance than some of the smaller stars. This clearly demonstrates that they are of very unequal magnitude.

NOTE 2.—There are now seven or eight well-attested cases of fixed stars suddenly glowing for a time with such brilliancy as to be visible in the day time, through the intensity of their light; then gradually fading away, and becoming entirely extinct. LAPLACE thinks that some great conflagrations, produced by extraordinary causes, have taken place on their surface.

NOTE 3.—The term universe, was until recently used to denote the whole creation of GOD, and was never used in the plural number; but astronomers use the term to denote an immense firmament or cluster of stars, entirely distinct from other clusters—of which there are many thousands visible with the telescope—and are at an immense distance from each other. Hence, in speaking of these clusters, they call them universes.—[PROF. MITCHELL.]

BINARY or DOUBLE STARS.

These Stars revolve around a common Centre of Gravity between them, and appear Single unless viewed with a Good Telescope.

GEMINI	CROWN	ORION	LION	NORTH STAR	BOOTES	HERCULES	VIRGO	GREAT BEAR	GREY HOUNDS	HARP
Castor	*Coronæ*	*Rigel*	*Leonis*	*Polaris*	*Izar*	*Ras Algethi*	*Virginis*	*Mizar*	*Hounds*	*Lyræ* *Vega*

TRIPLE STARS		QUADRUPLE STARS	QUINTUPLE STARS	SEXTUPLE STARS
Monoceros	*Librae*	*Lyræ*	*Cronis*	

Position of a Double Star in Ursa Major

1781 1802 1803

1219 1821½ 1826½

1829½ 1832½ 1836½

Position of two Stars in Castor

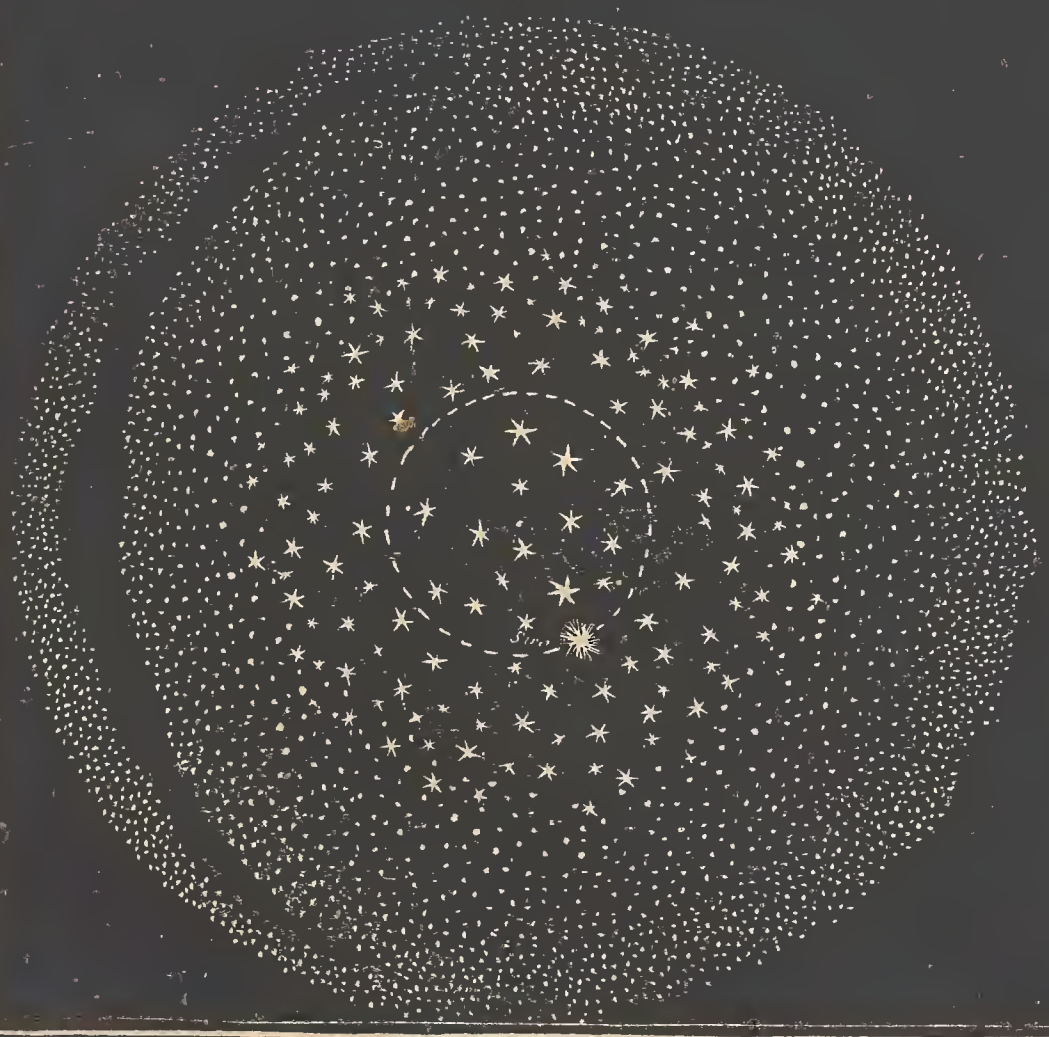
1719 1779 1962

1719 1826 1835-3

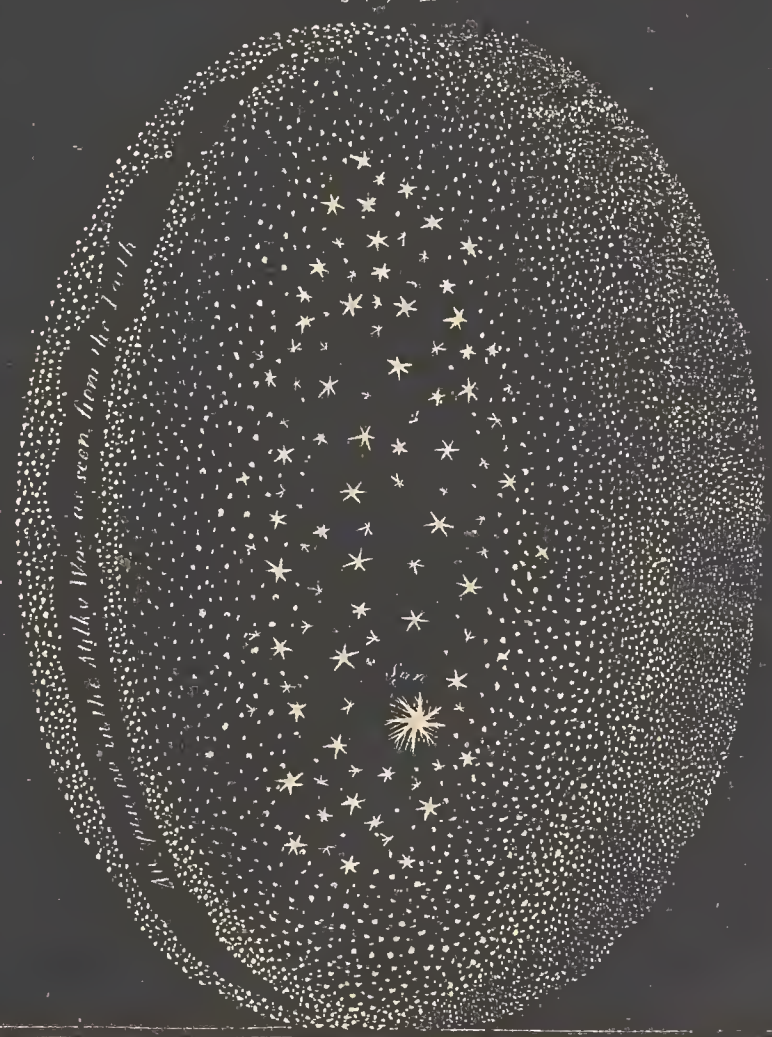
Position of two Stars in Virgo

1833 16th May | 1835 2nd May | 1836 26th May | 1836 3rd June

Our own Cluster or Firmament of Stars, in which the Sun is Situated.
Fig 1.



An Oblique View of the other Cluster.
Fig 2.



LESSON LIV.

NEBULÆ.

Question. What appearance has a nebula?

Answer. A nebula appears like a spot of pale light seen in the heavens.

Q. Of what are the nebulæ composed?

A. The most of them are great clusters of stars, so far distant as to appear like a thin cloud.

Q. Are there many of them?

A. About 6,000 have been discovered. (Note.—Their number is probably much greater; perhaps infinite.)

Q. What is the distance to these nebulæ?

A. Some of them are said to be so far distant, that light, traveling 192 thousand miles a second, would not reach us in less than 30 millions of years. [Prof. Mitchell.]

Q. Are they visible to the naked eye?

A. Only a few are seen without a telescope.

Q. How large do they appear when viewed with a telescope?

A. Some of them appear as large as one tenth of the disc of the moon.

Q. Are these nebulæ seen in all parts of the heavens?

A. They are, although they are more numerous in a narrow zone, circumscribing the heavens, at right angles to the milky way.

Q. Into how many classes may nebulæ be divided?

A. Into five classes, viz., resolved nebulæ, resolvable nebulæ, stellar nebulæ, irresolvable and planetary nebulæ.

Q. What are resolved nebulæ?

A. They are those which have been discovered with the telescope to be great clusters of stars.

Q. What are resolvable nebulæ?

A. They are those which are considered to be composed of stars, but are so far distant that the telescopes have not as yet resolved them.

Q. What are stellar nebulæ?

A. They are those of an oval or round shape, increasing in density towards the centre. (Note.—They sometimes present the appearance of having a dim star in the centre.)

Q. What are irresolvable nebulæ?

A. They are those which are considered to be luminous matter in an atmospheric state, condensing into solid bodies like the sun and planets.

Q. What are the planetary nebulæ?

A. They are those which resemble the disc of a planet, and are considered to be in an uncondensed state.

Q. Are all nebulæ beyond our cluster?

A They are, except the milky way, and nebulous stars.

Q. By what general term do astronomers designate each nebula or cluster?

A. They call each nebula a Universe, or Firmament.

Q. What can you say of the great nebula in the Greyhounds?

A. It resembles our own cluster, or firmament of stars.

Q. What can you say of the great nebula in Orion?

A. This nebula was considered to be luminous matter in an uncondensed state, but it has lately been discovered to be stars by Lord Rosse, with his powerful telescope. (Note.—This nebula is visible to the naked eye.)

Q. What is the probable cause of many of the nebulæ appearing elliptical or elongated? (See Diagram.)

A. It is probably caused by the edge of the nebula being turned more or less towards us.

ORIGIN OF THE SOLAR SYSTEM.

Many theories have been propounded at different periods of the history of Astronomy, respecting the original formation of our Solar System, as well as all other suns and systems, which it has pleased the great creator of all things to call into existence, but no one has gained so great favor or excited so violent opposition, as the theory first proposed by Sir William Herschel, and afterwards more especially applied by the celebrated La Place to the formation of the solar system.

This theory may be thus stated:—In the beginning all the matter composing the sun, planets, and satellites, was diffused through space, in a state of exceedingly minute division, the ultimate particles being held asunder by the repulsion of heat. In process of time, under the action of gravitation, the mass assumed a round or globular shape, and the particles tending to the centre of gravity, a motion of rotation on an axis would commence. The great mass, now gradually cooling and condensing, must increase its rotary motion, thereby increasing the centrifugal force at the equator of the revolving mass, until, finally, a ring of matter is actually detached from the equator, and is left revolving in space by the shrinking away from it, of the interior mass. If now we follow this isolated ring of matter, we find every reason to believe that its particles will gradually coalesce into a globular form, and in turn form satellites, as it was itself formed. It is unnecessary to pursue the reasoning further, for the same laws which produce one planet from the equator of the central revolving mass, may produce many—until finally, the process is ended by a partial solidification of the central mass, so great, that gravity aided by the attraction of cohesion, is more than sufficient to resist the action of the centrifugal force, and no further change occurs.

It has been urged in favor of this theory, that it accounts for the striking peculiarities which are found in the organization of the solar system. That the rings of Saturn are positive proofs of the truth of the theory, they having cooled and condensed without breaking. That the individuals constituting a system thus produced, must revolve and rotate as do the planets and satellites, and in orbits of the precise figure and position, as those occupied by the planets. It accounts for the rotation of the sun on its axis, and presents a solution of the strange appearance connected with the sun called the Zodiacal Light. It goes further and accounts for the formation of single, double, and multiple suns and stars—and by the remains of chaotic matter in the interstices between the stars, and which are finally drawn to some particular sun, whose influence in the end preponderates, accounts for the comets which enter our system from every region in space.

In support of this theory it has been urged that the comets, in their organization, present us with specimens of this finely divided nebulous or chaotic matter—and that the telescope reveals cloudy patches of light of indefinite extent, scattered throughout space, which give evidence of being yet unformed and chaotic. That many stars are found in which the bright nucleus or centre is surrounded by a halo or haze of nebulous light, and that round nebulous bodies are seen with the telescope, of an extent vastly greater than would fill the entire space encircled by the enormous orbit of the planet La Verrier, or having a diameter greater than 7000 millions of miles.

Such are a few of the arguments in support of this most extraordinary theory. We now present the objections which have been most strongly insisted on. The retrograde motions of the satellites of Herschel, and their great inclination to the plane of the ecliptic cannot be accounted for by this theory. That computation shows that no atmosphere of uncondensed nebulous matter can extend to so great a distance from the sun, as does the matter composing the Zodiacal Light, and, finally, that the nebulous matter in the heavens will ultimately be resolved into immense congeries and clusters of stars, whose great distance has hitherto defied the power of the best instruments.

In reply to the first objection, the friends of the theory doubt the facts with reference to the satellites of Herschel. They reply that the matter composing the Zodiacal Light, being in the nature of cometary matter, is thrown to a greater distance from the sun than gravity would warrant, by that power residing in the sun, which is able on the approach of comets to project those enormous trains of light, which sometimes render them so wonderful. As to the last objection, it is urged that although many nebulæ will doubtless be resolved into stars, by using more powerful telescopes, yet that these same telescopes will reveal more new nebulæ which cannot be resolved, than they will resolve—and as to the existence of nebulous matter, it is perfectly demonstrated by the physical organization of comets, and the existence of nebulous stars.

Such was the state of the Astronomical argument, when Lord Rosse's Great Reflector was first applied to the exploration of the distant regions of space. In a religious point of view, this theory had excited no small amount of discussion, in consequence of its supposed Atheistical tendencies. The friends of the theory contend that it was no more Atheistical to admit the formation of the universe by law, than to acknowledge that it is now sustained by laws. Indeed since we must go to the first great cause for matter in its chaotic state, as well as for the laws which govern matter, that this theory gave to us a grander view of the omniscience and omnipotence of God than could be obtained from any other source. In fine that it harmonized with the declaration of scripture, which tells us that "In the beginning God created the heavens and the earth, and the earth was *without form and void.*" If the earth came into existence in its present condition, then it had *form* and was *not void.* Hence, this first grand declaration of the inspired writer must refer to the formation of the matter, of which the heavens and earth were afterwards formed. Some went so far as to trace out dimly a full account of this theory in the order of creation, as laid down in Genesis.

Let us now proceed to the discoveries of Lord Rosse, and their influence on this greatly disputed theory. The space penetrating power of his six feet reflector is much greater than that of Sir William Herschel's great telescope, and it was anticipated that many nebulæ which were unresolved into clusters of stars by Herschel, would yield under the greater power and light of Lord Rosse's telescope. This has proved to be the fact. Very many nebulæ have been removed from their old places, and must hereafter figure among the clusters, while we are informed that many yet remain, even of the old nebulæ, which defy the power of the monster telescope.

The most remarkable object which has been resolved by Lord Rosse, is the great nebula in Orion, one of the most extraordinary objects in the heavens. (See Diagram.) Its size is enormous, and its figure very extraordinary. In certain parts adjoining the nebula the heavens are *jet black*, either from contrast or by the vacuity of these regions. Two immense spurs of light are seen to project from the principal mass of the nebula, and to extend to a most extraordinary distance. This will be better understood, by remembering that at the distance at which this nebula is removed from us, the entire diameter of the earth's orbit, 190 millions of miles, is an invisible point, less than one second, while this nebula extends to many thousands of times this distance, and more probably to many millions of times.

Several stars have been found, and are visible on the nebula, but have hitherto been regarded as being between the eye of the observer and this remote object. Sir William Herschel was unable to resolve this mysterious body, and yet the nebula gave indications of being of the resolvable kind, by its irregular and curdled appearance under high powers. Several years since Dr. J. Lamont, of Munich, after a rigid scrutiny of this nebula with his great Refractor, pronounced a portion of it to be composed of minute *stellar points*, and predicted its final perfect resolution into stars by greater power. This prediction has been fully verified, for Lord Rosse's great Reflector has solved the mystery, and filled this extraordinary object with the "jewelry of stars."

But the question recurs, what have the defenders of the nebular theory lost, or its enemies gained by this interesting discovery? We are all liable to reach conclusions too hastily, and to join issue on false points. If the nebular theory depended for its existence upon the irresolvability of the nebula in Orion, then indeed has the theory been entirely exploded. But this is not the fact. No one has asserted that the great nebula in Orion was *nebulous matter*, and if it were not, then none existed. Such an issue would have been a false one, had it been made.

The theory has neither lost nor gained by the discoveries thus far made; what time may develope it is impossible to say. In case certain data can be obtained, which appear to be accessible, then indeed may we demonstrate its truth or falsehood, by mathematical investigation Until then, the safer plan is neither to adopt nor reject, but investigate until absolute truth shall reward our long continued labor, and reveal the mystery of the organization of that stupendous system, of which our humble planet forms an insignificant part.

NEBULAE or CLUSTERS of STARS at an IMMENSE DISTANCE BEYOND OUR CLUSTER

The Stars Shown in these Figures have no connection with the Nebulae but belong to our own Cluster.

Resolved Nebulae

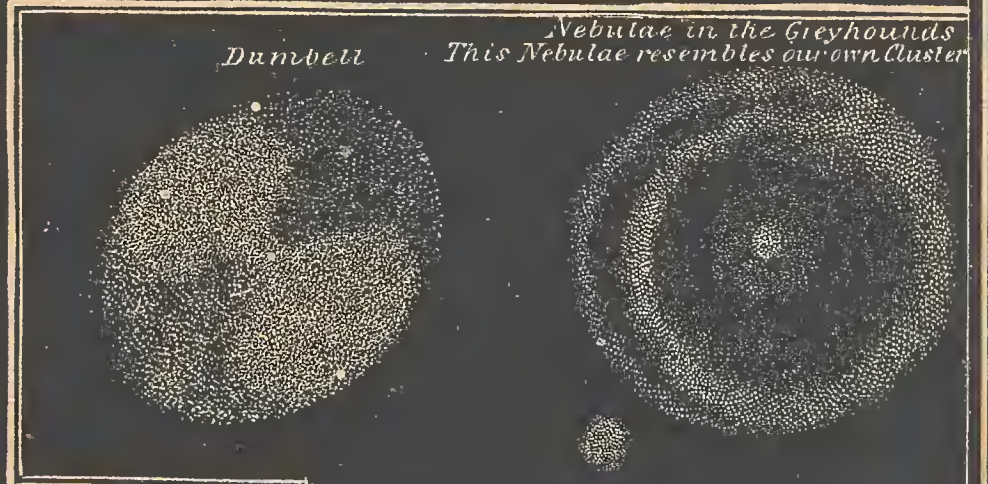
Stellar and Resolvable Nebulae

Double Nebulae

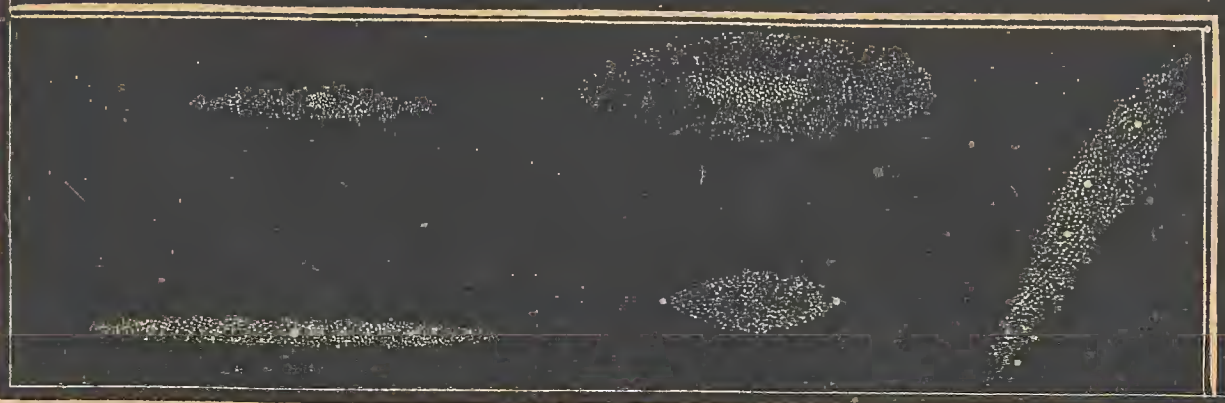
Hollow Nebulae

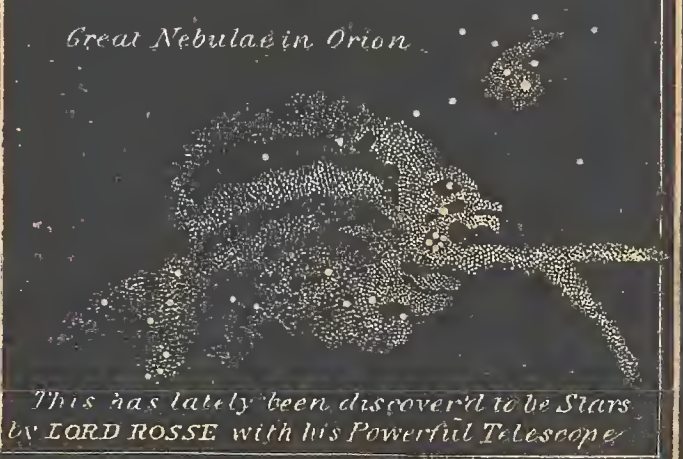
Irresolvable and Planetary Nebulae

Remarkable Nebulae



Elongated Nebulae





DESCRIPTION AND USE OF THE SIDEREAL MAPS.

These Maps have been drawn by the Author with great care, in order to insure perfect accuracy in their representations of the heavens at the times specified in the annexed tables. They have been constructed to show the sidereal hemisphere visible on the parallel of latitude and meridian of New York (City.) To insure the greatest amount of accuracy, the stereographic projection has been made use of, because of all projections that occasions the least possible disarrangement of the relative positions of the stars and the angles they form one with another. There is a difficulty in reducing a concave or globular surface to a plane without distortion taking place somewhere; and in the projection here adopted a little compression will be found, gradually increasing from the horizon to the centre of the map. The constellations near the zenith will be found to be somewhat smaller, and the stars nearer together, than when near the edge of the map or horizon. Several stars often appear in the heavens, so as to form a group, presenting the appearance of a triangle, a rhomboid, trapezium or parallelogram: these figures are more correctly preserved by this projection than by any other which might have been made use of. The centre of each map represents the zenith on the parallel of New York, or that point in the heavens directly over the observer's head at the time specified in the annexed tables. They will answer equally well for any place within the United States, by making an allowance for the situation of the place north or south of the parallel of New York. For instance, to an observer at Washington the zenith, as represented on the maps, would be about $3\frac{1}{2}$° degrees to the north of his zenith; also, to an observer at New Orleans the zenith of the maps would be about 12° degrees to the north: at Quebec the zenith of the maps would be about 6° degrees to the south; but to all places in the New England, Middle, and Western States, the variation would be so small that it would hardly be perceptible, unless by accurate observation. As we go north or south our sidereal hemisphere is continually changing. If we go north new stars seem to emerge from the northern horizon, while those near the southern horizon disappear below it; and if we should continue our journey to the north pole, we should find the north star in the zenith, or directly over head, and that the stars visible to us did not rise nor set, but described circles around the north star every 24 hours; these circles increasing in diameter, according to the distance of the star from the north star. To a person thus situated, the equator would be in the horizon, and he would see none of the stars in the southern hemisphere. If there were inhabitants at the south pole they would be similarly situated with regard to the stars in the southern hemisphere; they would never see the stars on the north side of the equator or in the northern hemisphere, nor would the stars in the southern hemisphere ever set to them. To the inhabitants at the equator, the whole of the stars, from pole to pole, would rise and set perpendicularly to their horizon once in every 24 hours. As the equator has no latitude, so has its zenith no declination, because the celestial equator is directly over it on a line from east to west. If an observer moves towards either pole from the equator, for every degree of his progress his zenith will have just so many degrees of declination, and as many degrees can he see beyond the pole towards which he is advancing; and he will lose sight of the pole from which he is receding in the same proportion. For example, as the inhabitants of New York are situated near 41° degrees north of the equator, their zenith is elevated 41° degrees above the celestial equator; and it follows that the inhabitants on the parallel of New York can see all the stars within 49° degrees south of the equator—for 41° added to 49° makes 90°—the distance from the zenith to the horizon; also between the zenith of New York and the north pole, are 49° degrees; requiring 41° degrees beyond the pole to make up the complement of 90 degrees; consequently the stars 41° degrees beyond the north pole never set to the inhabitants living on the parallel of New York, but describe circles, or appear to revolve around the pole star every 24 hours.

EXPLANATIONS, SHOWING THE MANNER OF USING THE MAPS.

The pupil should be particularly instructed in the manner of using these maps, or they will be inclined to use them in the same manner as they do the maps of a Geography or Atlas, which will confuse and confound them. In using a geographical map the pupil is instructed to face the north, and lay the map before him; then the top represents the north, the right hand east, &c.: but it will be observed, that if this mode be adopted with these maps, the right hand represents the west and the left hand the east. Each map is intended to represent the whole visible heavens at the time given for observation; hence, if we face the south, and hold the map up over the head, with the pole star directed towards the north star in the heavens, it will then represent nearly the condition of the heavens. In viewing the stars south of our zenith, face the south, and hold the map up in front of the eye; but in viewing the stars to the north of our zenith, face the north, turn the map bottom upwards, and hold it so that the pole star on the map shall correspond with the pole star in the heavens, then the stars on the map will indicate the positions of the stars in the heavens. In viewing the stars to the east, face the east, and hold the map up before the eye, with the top turned towards the north; the map will then indicate the correct positions of the stars: also, in viewing the stars to the west, face the west, and hold the map up before the eye, with the top turned towards the north. Great care should be taken when an observation is made, so as not to mistake the planets Venus, Mars, or Jupiter, for fixed stars.

DIRECTIONS FOR FINDING THE NORTH STAR, AT ANY TIME.

Every pupil should be instructed in the manner of pointing out the North Star at any time of the night. If they are enabled to do this at any time, it will assist them in making other important observations, as well as being of use on many occasions which occur in the life of every man. Many persons have been lost in a prairie or other unfrequented places, when if they had been able to have told the points of the compass they could have extricated themselves from their lost situation. This may be done in a very easy manner. There is hardly a child of 10 years of age who cannot at any time of night point out the stars in the Great Bear which form what is called the Great Dipper. Now if an imaginary line be drawn through the two stars which form the front edge of the Dipper, from the bottom towards the top, and continued about 20° degrees, it will pass very near the North Star—so near that it cannot be mistaken, there being no other stars of that magnitude near it. It should be borne in mind that this rule holds good in whatever position the Dipper may be at the time.

PRINCIPAL CONSTELLATIONS VISIBLE, FROM JANUARY 21 TO APRIL 17.

Ursa Major, the Great Bear.—The first seven stars in this constellation form what is called the Great Dipper. It is situated about 15 degrees north of the zenith, and a little to the east of north. It is exactly bottom upwards, with the handle towards the east. There are four stars which form the dipper, and three in the Tail of the Bear, which form the handle. These stars cannot fail to be recognized at a glance. Six of these stars are of the second and one of the third magnitude. The first two, α, β., are called pointers, as a line drawn through them towards the horizon would pass very near the North Star, which is about 30 degrees from them towards the horizon.

Ursa Minor, the Little Bear.—The stars in this constellation form a figure called by some a Wagon, and by others the Little Dipper. It is north of the Great Dipper and east of the North Star, which is in the end of the handle. The North Star is at the end of the tail of the Little Bear.

Taurus, the Bull.—The star α, or Aldebaran, is one of the first magnitude, and is in the right eye of the Bull; hence, it is sometimes called the Bull's Eye. This constellation is situated nearly west, and about 20 degrees above the horizon. The cluster of stars on the head of the Bull is called the Hyades. There is a small cluster of stars on the neck of the Bull, and north of the word Taurus on the map. It consists of seven stars, very near together. This group is called the Pleiades, or Seven Stars. Six of these stars only are visible to the naked eye.

Orion.—This is one of the most remarkable constellations in the heavens, and was familiarly known to the ancient writers, Job and Homer. It contains two stars of the first magnitude, Betelgeuse on the right shoulder, and Rigel on the left foot, of Orion. Half way between these two stars are three stars in the girdle, in a right line, forming Jacob's Staff, or the Three Kings, as they are sometimes called. There is a large nebula seen in this constellation, or rather through it, as the nebula is at an immense distance beyond the stars. According to fable Orion was a mighty hunter, who accompanied Diana and Latona in the chase.

Gemini, the Twins.—The two principal stars in this constellation are (α) Castor and (β) Pollux; one in the head of each Twin.

Canis Minor, the Little Dog.—This constellation contains two large stars, (α) or Procyon, of the first, and (β) Mirza, of the third magnitude, besides several small stars. This constellation was said to be one of the hounds of Orion.

Canis Major, the Great Dog.—This constellation is to the southeast of Orion, and contains the star Sirius, the brightest star in the whole heavens. This is said by the Greeks to be one of Orion's hounds—but the Egyptians, no doubt, gave it the name of Dog, from the fact that it gave them warning of the approach of the inundation of the waters of the Nile. When this star was seen in the direction of the source of the Nile they moved back from the river upon the high ground—and as the dog was ever watchful to announce the approach of danger, they gave the same name to this star, which they fancied warned them, although silently, of approaching danger.

Leo Major, the Great Lion.—The principal star in this constellation is (α) or Regulus: it is on the meridian at the time for observation, and about 30 degrees south of the zenith. There are several bright stars in this constellation. The stars in the head and neck form a curve somewhat like a sickle, Regulus being in the end of the handle. This Lion was supposed to be a metamorphosis of the Nemæan Lion, which was slain by Hercules.

Bootes, the Herdsman.—This is a very large constellation, southeast of the Great Bear. The principal stars are (α) Arcturus, of the first magnitude, and (ε) Izar of the second magnitude. This star is situated in the Belt of Bootes. This constellation is of great antiquity; so much so that it is doubtful from whence it derived its name. Bootes is represented as walking, holding in his right hand a spear, and in his left the leading cords of the two dogs Asterion and Chara, which seem to be barking at the Great Bear.

Virgo, the Virgin.—This constellation is east of Leo. The principal star is (α) Spica, of the first magnitude, in the ear of corn, which the Virgin holds in her left hand, and is the only bright star in this constellation. The position of this star has been determined with great exactness for the benefit of navigators. It is situated within the zone, in the heavens traversed by the moon. The moon's distance from the star is used for determining the longitude at sea. According to the ancient poets, this constellation represented the virgin Astræa, the goddess of Justice, who lived upon the earth during the golden age; but being offended at the wickedness of mankind, during the brazen and iron ages of the world, she returned to heaven, and was placed among the constellations of the zodiac, with a pair of scales (Libra,) in one hand and a sword in the other.

Corvus, the Crow.—This is a small constellation south of the virgin. It contains four bright stars, forming a trapezium or irregular square. The brightest of the two upper stars, on the left, is called Algorab, in the east wing of the crow. The crow, it was said, was once of the purest white, but was changed to black, its present color, as a punishment for tale bearing.

Corona Borealis, the Northern Crown.—This is a small constellation between the head of Bootes and Hercules. It may be distinguished by six principal stars, which form a circular figure, resembling a wreath or crown. This beautiful cluster of stars was said to be in commemoration of a crown presented by Bacchus to Ariadne. the daughter of Minos, second king of Crete.

Draco, the Dragon.—This constellation coils its fore part around the pole of the Ecliptic, and its tail around the Pole Star. In consequence of its various windings, perhaps it may be found difficult to be traced. According to fable, Draco, the offspring of Typhon, with a hundred heads and as many voices, was the guardian of the golden apples that grew in the garden of Hesperides. He was slain by Hercules, who obtained the apples, and presented them to Eurystheus.

Canes Venatici, the Grey Hounds.—This constellation contains only small stars. These two hounds, which Bootes leads with a small cord, are named Asterion and Chara.

Coma Berenices—Berenices Hair.—This is a small constellation between the Greyhounds, on the north, and the Virgin, on the south. It contains only small stars.

Crater, the Cup.—This cup is south of the Great Lion, and east of the Crow. It contains seven stars, so situated as in some degree to resemble the outline of a cup. According to fable, Jupiter sent the Crow with a cup to fetch water; but the bird being of a vagrant disposition, wasted his time, and returning without the water, told Apollo that the stream was guarded by a venomous serpent. To punish the Crow for this falsehood, Apollo placed him opposite the cup, and commanded the serpent never to allow him to drink.

Hydra, the Water Serpent.—This is a very long constellation, extending over 100 degrees from west to east. It may be known by four small stars south of the Crab, and nearly west of Regulus. This was supposed to be the Lernæan Hydra, which Hercules slew.

Sextans, the Sextant.—This constellation was formed by Hevelius of stars not included in the other adjacent constellations. It contains only small stars.

Argo Navis, the Ship Argo.—This constellation is in the southern horizon. The head of the ship may be known by a small cluster of stars about 15 degrees of the dog star Sirius. The greater part of this constellation is below the horizon. Some said this was the celebrated ship in which Jason and his companions went to Colchis, in quest of the golden fleece, which had fled from Greece. Others maintained that the ship Argo was no other than the Ark of Noah.

MAP, FROM JANUARY 21 TO APRIL 17.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. By occasional observations with these Maps, the pupil will become familiar with all the Stars of the first magnitude as well as the principal Constellations. The great advantage these Maps have over all others, is, that they show the whole visible heavens at the time given for observations, and the exact positions of the Stars from the observer as well as from each other. For example:—On the 21st of January, at 1 o'clock 40 minutes in the morning, the Stars occupy the same positions in the heavens as laid down on the Map. The Star Regulus, of the first magnitude, will be exactly on the meridian, and about 26° degrees south of the zenith; Procyon, or the Little Dog, about 35° degrees west of Regulus; and Sirius, or the Great Dog, southwest of Procyon, and near the horizon. In this manner the pupil will be able to trace out the principal Stars and Constellations with facility. There are many Sectional Maps published, but they are all subject to this one great objection—which is, the great difficulty the pupil has in locating it. This objection is entirely obviated in these Maps.]

STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

LEO, The Lion—(**Regulus,** the principal star.)—This star is 26° south of the zenith, and on the meridian at the times specified in the Table for Map No. 1.

VIRGO, The Virgin—(**Spica.**)—This star is southeast, and about 20° above the horizon.

BOOTES, The Herdsman—(**Arcturus.**)—This star is situated nearly east, and about 40° from the horizon.

LYRA, The Harp—(**Vega.**)—This star is nearly northeast, and near the horizon.

CYGNUS, The Swan—(**Deneb.**)—This star is about 22° east of north, and very near the horizon, and perhaps not visible unless the atmosphere is very clear, and the observer situated upon an eminence.

AURIGA, The Charioteer—(**Capella.**)—This star is nearly northwest, and about half way from the zenith to the horizon.

TAURUS, The Bull—(**Aldebaran.**)—This star is in the eye of the Bull, and nearly west, and about 20° above the horizon.

ORION, Orion—(**Betelgeuse.**)—This star is in the right shoulder of Orion, a little south of west, and about 30° above the horizon.

ORION, Orion—(**Rigel.**)—This star is in the left foot of Orion, southwest of Betelgeuse, and very near the horizon.

CANIS MINOR, Little Dog—(**Procyon.**)—This star is situated southwest, about 45° degrees from the horizon.

CANIS MAJOR, Great Dog—(**Sirius.**)—This star is southwest of Procyon, about 20° from the horizon. This is the brightest star in the heavens, and was considered the nearest; but late observations have demonstrated to the contrary.

TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

		H.	M.
JANUARY	21	1	40
....	22	1	36
....	23	1	32
....	24	1	28
....	25	1	24
....	26	1	20
....	27	1	16
....	28	1	12
....	29	1	8
....	30	1	4
....	31	1	—
FEBRUARY	1	12	56
....	2	12	52
....	3	12	48
....	4	12	44
....	5	12	40
....	6	12	36
....	7	12	32
....	8	12	28
....	9	12	24
....	10	12	20
....	11	12	16
FEBRUARY	12	12	12
....	13	12	8
....	14	12	4
....	15	12	—
....	16	11	56
....	17	11	52
....	18	11	48
....	19	11	44
....	20	11	40
....	21	11	36
....	22	11	32
....	23	11	28
....	24	11	24
....	25	11	20
....	26	11	16
....	27	11	12
....	28	11	8
MARCH....	1	11	4
....	2	11	—
....	3	10	56
....	4	10	52
....	5	10	48
MARCH....	6	10	44
....	7	10	40
....	8	10	36
....	9	10	32
....	10	10	28
....	11	10	24
....	12	10	20
....	13	10	16
....	14	10	12
....	15	10	8
....	16	10	4
....	17	10	—
....	18	9	56
....	19	9	52
....	20	9	48
....	21	9	44
....	22	9	40
....	23	9	36
....	24	9	32
....	25	9	28
....	26	9	24
....	27	9	20
MARCH...	28	9	16
....	29	9	12
....	30	9	8
....	31	9	4
APRIL.....	1	9	—
....	2	8	56
....	3	8	52
....	4	8	48
....	5	8	44
....	6	8	40
....	7	8	36
....	8	8	32
....	9	8	28
....	10	8	24
....	11	8	20
....	12	8	16
....	13	8	12
....	14	8	8
....	15	8	4
....	16	8	—
....	17	7	56
.....			

VISIBLE HEAVENS FROM JANUARY 21ST TO APRIL 17TH

LACERTA
ANDROMEDA
CASSIOPEA
CYGNUS
CEPHEUS
LYRA
TRIANGULUM
HERCULES
DRACO
LIBRA MINOR
POLE STAR
CAMELOPARDALIS
PERSEUS
ARIES
TAURUS
CORONA BOREALIS
SERPENS
BOOTES
CANES VENATICI
URSA MAJOR
LYNX
AURIGA
ZENITH
COMA BERENICES
ERIDANUS
LIBRA
EQUATOR
GEMINI
ORION
CANUS MINOR
CANCER
LEO
VIRGO
ECLIPTIC
MONOCEROS
Milky Way
LEPUS
SEXTANS
CANIS MAJOR
CORVUS
CRATER
ARGO NAVIS
HYDRA

STARS VISIBLE

N°		MAG
11	of the 1st	✱
34	2nd	✱
91	3rd	+
207	4th	·
535	5th	⁘

AN EXPLANATION OF LEAP-YEAR.

It has been found by observations, that the earth revolves on its axis 365¼ times nearly, while it is making one complete revolution around the sun, or while the sun moves from either equinox to the same equinox again; consequently the solar year, upon which the seasons depend, contains nearly 365¼ days. It will be seen from this that the difference between a year of 365 days and the year as measured by the sun, amounts to one day in every four years; so that in 120 years of 365 days, the seasons would fall back one whole month, or 30 days, and the season for May would be in June, and the season for June would be in July, &c. In 720 years the longest days would be in the month of December: but in about 1450 years the season would fall back through the twelve months, and would again correspond to their present arrangement. In order to keep the seasons to the same months, and to make the solar and civil year correspond, one day more is included in the month of February, every fourth year. This would always keep the solar and civil year together, if the earth revolved upon its axis exactly 365¼ times while it was revolving around the sun, or during the solar year; but the earth revolves from one equinox to the same again in 365 days, 5 hours, 48 minutes, 49 seconds; which is 11 min. 11 sec. less than 365¼ days: consequently, in allowing one day in every four years is allowing 44 min. 44 sec. too much; and in 132 years it would amount to 24 h. 36 min. 6 sec., or more than one day: so that the longest day, which is now on the 21st of June, would, in 132 years, be on the 20th of June, or one day earlier, and in 264 years the longest day would be on the 19th of June, and so on.

This mode of reckoning time, by making every fourth year a leap-year, was adopted by the Council of Nice, in the year of our Lord 325, when the longest day in the year happened June 21st, and the vernal equinox March 21st. This mode of reckoning was continued from the year 325, to 1752, a period of 1427 years; when it was found that the longest day was on the 10th of June, and the vernal equinox on the 10th of March; the vernal equinox having fallen back 11 days towards the beginning of the year. To restore the equinoxes to the same days of the month in which they happened in the year 325, eleven days were ordered, by the British Government, and the United States, then British colonies, to be stricken out of the month of September, 1752, by calling the 3d day the 14th; and it was ordered that hereafter one leap-year in every 132 years, or 3 leap-years in 400 years, should be omitted: that is, that the years 1700, 1800, and 1900, which by the Old Style would have been leap-years, should be common years of 365 days. This method gives 97 leap-years in every 400 years. Thus 400 multiplied by 365, plus 97 days for the leap-years, gives 146,097 days. This divided by 400 years makes 365 days 5 h. 49 min. 12 sec.; making a difference from the true solar year of only 23 seconds a year; an error which amounts only to one day in 3,866 years.

This new arrangement is called the New Style.

This change was made to keep the equinoxes and solstices to the same days of the same months, and to keep the time of celebrating Easter, and the other feasts, fasts, and holydays of the Episcopal Church, to the same seasons of the year. The Russians and some other eastern nations continue the Old Style at the present day. The year 1800 was not a leap year by the New Style, but would have been by the Old Style: the difference between the styles is now 12 days.

RULE FOR ASCERTAINING WHAT YEARS ARE LEAP-YEARS.

Divide the years by 4, and if there is no remainder it is Leap-Year; if there is 1 remainder, it is the 1st year after the leap-year; if there is 2 remainder, it is the 2d; if there is 3 remainder, it is the 3d year after leap-year. The even centuries are leap-years only when, by cutting off the two cyphers, you can divide the other two figures without a remainder. Thus 19(00 is not divisible by 4 without a remainder—consequently it is not a leap-year. The years 2,000, 2,400, 2,800, &c. are leap-years; and 2,100, 2,200, 2,300, 2,500, 2,600, and 2,700 are not leap-years.

EQUATION OF TIME.

It is observed that time, as measured by the sun, differs from that shown by a clock that keeps true and equal time: the solar day, or time from the sun's leaving the meridian of any place till he leaves the same again, being sometimes less than 24 hours, and sometimes more; that is, if by a true clock, on any day, the sun leaves the meridian of any place at just 12 o'clock, it is either a few seconds *before* or a few seconds *after* 12, when he leaves that meridian the next time: it is a few more seconds, either *before* or *after* 12, when he leaves that meridian again; and so on, till in a few weeks it is several minutes *before* or *after* 12 by the clock when the sun leaves the meridian.

It is, in fact, the place, and the meridian of the place, that leaves the sun; but we say the sun leaves the meridian, because by the motion of the earth round its axis, the sun appears to move round the earth every day; and by the motion of the earth round the sun, the sun appears to move in the ecliptic round the earth once a year. The motion of the earth round its axis is always uniform and equal, never faster at one time than at another; this is the only perfectly uniform and equal motion known: and the mean or average time of its revolution from the sun to the sun again is 24 hours; that is, the *average* or *mean time* from the sun's leaving the meridian of any place, till he leaves the same again, is 24 hours; though, as before said, it is sometimes more and sometimes less.

The difference between the time of the sun's leaving the meridian, and 12 o'clock, by a true clock, is called The Equation of Time: at greatest it is 16 min. 15 sec.; this is on the last of October, and first of November. On the 14th of April, 15th of June, 31st of August, and 23d of December, this equation or difference is nothing, as then the sun and clock agree; and these are the only days in the year on which the sun and clock *do* agree.

The Equation depends on two causes;—viz. 1. The unequal motion of the sun in the ecliptic;—And, 2. The obliquity of the ecliptic to the equator.

It has already been shown that the sun, as well as the moon, moves much slower when in or near its apogee, than when in or near its perigee; and that its *true* place is never the same as its *mean* place, except in apogee and perigee. Now as the motion of the earth round its axis on the side next the sun, is in the same direction as the apparent motion of the sun in the ecliptic, it is plain that the slower the sun moves, the sooner will any place on the earth's surface move round from the sun to the sun again; or the shorter will be the solar day; because as the earth revolves round its axis, any place on the earth's surface will overtake the sun in less time when he advances through a less space, than when he moves through a larger.

The first equation depends upon the sun's distance from the perigee or perihelion, and is the difference between the *mean* and *true* place of the sun, changed into time. It is greatest when the sun is half way between the aphelion and perihelion, and nothing when it is in the aphelion or perihelion. The sun is faster than the clock while it is moving from the aphelion to the perihelion, and slower, while it is moving from the perihelion to the aphelion. This difference, between the sun and clock, when greatest, is 7 min. 42 sec.

The second equation, depending upon the obliquity of the ecliptic to the equator, at greatest, is 9 min. 53 sec.—(*Spofford's Astronomy, page* 29.)

PRINCIPAL CONSTELLATIONS VISIBLE, FROM APRIL 18 TO JULY 21.

Corona Borealis, the Northern Crown.—This constellation is about 15 degrees southwest of the zenith. Six of the principal stars form a circular figure resembling a wreath or crown.

Bootes, the Herdsman.—This constellation is situated west of the Crown. The principal star is ARCTURUS.

Hercules.—This constellation is east of CORONA or the Crown, and extends from 12 to 50 degrees, north declination. It contains one hundred and nineteen stars—one of the 2d magnitude and one of the 3d in the right shoulder. These are called BETA and GAMMA. The left or east arm of Hercules grasps the three headed monster CERBERUS.

According to mythology, this constellation is intended to immortalize the name of Hercules, the Theban, so celebrated in antiquity for his heroic valor and invincible prowess. By command of Eurystheus, he achieved a number of enterprises, the most difficult and arduous ever known, called the TWELVE LABORS OF HERCULES.

1st. He subdued the Nemæan Lion in his den, and clothed himself in his skin.

2d. He slew the LERNÆAN HYDRA, with a hundred hissing heads, and dipped his arrows in the gall of the monster, to render their wounds incurable.

3d. He took alive the stag with golden horns and brazen feet, which was famous for its incredible swiftness, after pursuing it for twelve months, and presented it unhurt to Eurystheus.

4th. He took alive the Erimanthean Boar, and killed the Centaurs which opposed him.

5th. He cleansed the stables of Augias, where 3,000 oxen had been confined for many years.

6th. He killed the carnivorous birds which ravaged the country of Arcadia, and fed on human flesh.

7th. He took alive, and brought into Peloponnesus, the wild bull of Crete, which no mortal durst look upon.

8th. He obtained for Eurystheus the Mares of Diomedes, which lived on human flesh, after having given their owner to be first eaten by them.

9th. He obtained the girdle of the Queen of the Amazons, a formidable nation of warlike females.

10th. He killed the monster Geryon, king of Gades, and brought away his numerous flocks, which fed upon human flesh.

11th. He obtained the Golden Apples from the Garden of Hesperides, which were watched by a dragon.

12th. He finally brought up to the earth the three headed dog Cerberus, who guarded the entrance to the infernal regions.

Lyra, the Harp.—This is a small but beautiful constellation. It contains (α) VEGA, one of the brightest stars in the northern hemisphere, and is situated directly east, and between 30 and 45 degrees from the zenith.

It is asserted that this is the celestial Lyre which Apollo or Mercury gave to Orpheus, and upon which he played with such a masterly hand, that even the most rapid rivers ceased to flow; the wild beasts of the forest forgot their wildness, and for the time being became tame, and the mountains came to listen to his song.

Aquila, the Eagle.—This constellation may be easily found by three stars in a right line; ALTAIR, of the first magnitude, midway between the other two.

This constellation is supposed to have been Merops, a king of the Island of Cos, who was transformed into an Eagle, and placed among the constellations.

Delphinus, the Dolphin.—This is a beautiful little cluster of stars, and may be easily distinguished by four principal stars in the form of a diamond. The Dolphin was made a constellation for persuading the goddess Amphitrite, who had made a vow of perpetual celibacy, to become the wife of Neptune.

Ophiuchus, the Serpent Bearer.—This constellation is represented as a man with a long beard, holding in his clenched hands a prodigious Serpent, which is writhing in his grasp. This constellation occupies a large space, from 15° north to 25° south of the equator. The principal star is RAS ALHAGUE, of the second magnitude, situated in the head. The star on the foot just south of the ecliptic is RHO. According to mythology, OPHIUCHUS or ESCULAPIUS, as he was sometimes called, was the god of Medicine. He was the son of Apollo, but was killed by Jupiter with a thunderbolt, for restoring Hippolytus to life.

Scorpio, the Scorpion.—This is one of the constellations of the zodiac. It is a very beautiful group, as it contains one star of the first, two of the second, and eleven of the third magnitude. (α) Antares, of the first magnitude, is situated in the heart of the SCORPION. It is a little east of the meridian, and about 20 degrees above the horizon. Orion, a celebrated giant, having impiously boasted that there was no animal on earth which he could not subdue, DIANA, whom he had offended, sent a Scorpion, which stung him to death.

Serpens, the Serpent.—This constellation is united with that of OPHIUCHUS, who holds the serpent in his grasp. It may be distinguished by several bright stars in and near the head

Libra, the Scales.—This constellation contains 4 stars of the 2d magnitude, by which it may be distinguished; two of them being about 10 degrees northwest of Antares in the Scorpion. About twenty-two hundred years ago this constellation coincided with the sign Libra of the ecliptic, and when the sun entered this constellation the days and nights were equal; hence it was very appropriately represented by the ancients by a pair of scales, which denote equality.

Scutum, or Sobieski's Shield.—This is a small constellation, instituted by HEVELIUS. It may be known by three small stars in the form of a triangle.

Vulpecula et Anser—(THE FOX AND GOOSE.)—This constellation was also established by HEVELIUS, and is situated south of the Swan and north of the Dolphin and Eagle. It contains only small stars.

MAP, FROM APRIL 18 TO JULY 21.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be eight stars of the first magnitude visible, the most conspicuous of which will be Arcturus, Vega, Altair, Deneb, Antares, and Spica. The other two being near the horizon, may not be visible unless the atmosphere is very clear.]

STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

BOOTES, The Herdsman—(**Arcturus** the principal star.)—This star is situated towards the southwest, and about 30° from the zenith.

VIRGO, The Virgin—(**Spica.**)—This star is almost in a direct line southwest of Arcturus, and about 30° above the horizon.

LYRA, The Harp—(**Vega.**)—This star is due east and about 37° from the zenith.

LEO MAJOR, The Great Lion—(**Regulus.**)—This star is due west, and about 10° above the horizon—perhaps not visible unless the atmosphere is very clear.

AQUILA, The Eagle—(**Altair.**)—This star is nearly southeast of Vega, and about half way from Vega to the horizon.

CYGNUS, The Swan—(**Deneb.**)—This star is nearly northeast of the zenith and east of the North Star.

AURIGA, The Charioteer—(**Capella.**)—This star is about 16° west of north, and very near the horizon; perhaps not visible.

SCORPIO, The Scorpion—(**Antares.**)—This star is nearly south, being only about 20° east of the meridian. It is about 30° above the southern horizon. There are two stars of the second magnitude about 10° to the northwest of it.

TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

		H.	M.
APRIL.....	18	2	16
....	19	2	12
....	20	2	8
....	21	2	4
....	22	2	—
....	23	1	56
....	24	1	52
....	25	1	48
....	26	1	44
....	27	1	40
....	28	1	36
....	29	1	32
....	30	1	28
MAY.....	1	1	24
....	2	1	20
....	3	1	16
....	4	1	12
....	5	1	8
....	6	1	4
....	7	1	—
....	8	12	56
....	9	12	52
....	10	12	48
....	11	12	44

		H.	M.
MAY.....	12	12	40
....	13	12	36
....	14	12	32
....	15	12	28
....	16	12	24
....	17	12	20
....	18	12	16
....	19	12	12
....	20	12	8
....	21	12	4
....	22	12	—
....	23	11	56
....	24	11	52
....	25	11	48
....	26	11	44
....	27	11	40
....	28	11	36
....	29	11	32
....	30	11	28
....	31	11	24
JUNE.....	1	11	20
....	2	11	16
....	3	11	12
....	4	11	8

		H.	M.
JUNE.....	5	11	4
....	6	11	—
....	7	10	56
....	8	10	52
....	9	10	48
....	10	10	44
....	11	10	40
....	12	10	36
....	13	10	32
....	14	10	28
....	15	10	24
....	16	10	20
....	17	10	16
....	18	10	12
....	19	10	8
....	20	10	4
....	21	10	—
....	22	9	56
....	23	9	52
....	24	9	48
....	25	9	44
....	26	9	40
....	27	9	36
....	28	9	32

		H.	M.
JUNE...	29	9	28
....	30	9	24
JULY.....	1	9	20
....	2	9	16
....	3	9	12
....	4	9	8
....	5	9	4
....	6	9	—
....	7	8	56
....	8	8	52
....	9	8	48
....	10	8	44
....	11	8	40
....	12	8	36
....	13	8	32
....	14	8	28
....	15	8	24
....	16	8	20
....	17	8	16
....	18	8	12
....	19	8	8
....	20	8	4
....	21	8	—
.....			


VISIBLE HEAVENS FROM APRIL 18TH TO JULY 21ST
EAST
WEST
PERSEUS
AURIGA
CAMELOPARDALUS
LYNX
GEMINI
CANCER
PEGASUS
ANDROMEDA
MILKY WAY
CASSIOPEA
CEPHEUS
POLAR STAR
URSA MINOR
URSA MAJOR
LEO MINOR
LEO
DRACO
TRIANGULUM
VULPECULA
DELPHINUS
LYRA
EQUULEUS
EQUATOR
AQUARIUS
AQUILA
HERCULES
CORONA BOREALIS
BOOTES
CANES VENATICI
COMA BERENICES
CAPRICORNUS
SERPENS
VIRGO
CRATER
SCUTUM
OPHIUCHUS
LIBRA
ECLIPTIC
CORVUS
SAGITTARIUS
HYDRA
SCORPIUS
CENTAURUS
LUPUS
STARS VISIBLE
No.
MAG
8 of the 1st
39 2nd
102 3rd
210 4th
511 5th

PRINCIPAL CONSTELLATIONS VISIBLE, FROM JULY 22 TO OCTOBER 31.

Cygnus, the Swan.—This constellation is situated a little to the west of the zenith. It is represented with outspread wings, flying in the direction of the MILKY WAY to the southwest. The five principal stars are so arranged as to form a large and regular Cross. Deneb, a star of the first magnitude, is in the head of the Cross, and ALBIREO, situated in the beak of the Swan, forms the foot. Over the right wing of the Swan is a remarkable double star, known by the name of "61 Cygni." These stars are of the 5th and 6th magnitude; they revolve round a common centre of gravity between the two, in 540 years. These two stars will ever be memorable as being the first whose distance from us was measured with much precision, and are the nearest to us, with a single exception, of any as yet known. The star (α) Centauri is about one-third the distance of 61 Cygni. Observations have been made on a great many others; but their parallax is much less, and in most cases is so small as not to be perceptible with the most accurate instruments. The distance of 61 Cygni was ascertained by BESSEL, from his observations, in the years 1837, 1838 and 1839. He found their distance 592,000 times the earth's mean distance from the sun. So great is this distance, that a CANNON BALL, moving 500 miles an hour, would not reach those two stars in less than thirteen millions of years. The sun, seen from these stars, would appear like a star of the 5th magnitude. Previous to this discovery the stars were considered to be about the same in magnitude, and the brightest stars to owe their brilliancy to their being nearer to us; but the brightest star in the whole heavens (Sirius, the great Dog Star,) is at a much greater distance than these, and owes its brilliancy to its superior magnitude or much greater brilliancy.

Lyra, the Harp.—This constellation is next to the SWAN. For a description of this constellation, see explanations to Map No. 2, from April 18 to July 31.

Cepheus, the King.—This constellation may be known by three stars of the third magnitude in a right line—in the neck, breast, and knee. He stands with his left foot over the pole. He holds a sceptre in his hand, extended towards Cassiopeia, his wife. CEPHEUS was the king of Ethiopia: the name of his queen was Cassiopeia. He was one of the ARGONAUTS who accompanied JASON in his expedition from Greece to Colchis, in quest of the Golden Fleece, and at his death was changed into a constellation.

Cassiopeia, the Lady in her Chair.—This constellation is situated east of CEPHEUS. She is represented in regal state, seated on a throne or chair, holding in her left hand the branch of a palm tree. She is surrounded by her royal family—CEPHEUS, her husband, on her right hand; PERSEUS, her son-in-law, on her left, and ANDROMEDA, her daughter, just above her. This constellation contains 55 stars, that are visible to the naked eye: five of these are of the 3d magnitude, which, with two smaller ones, form a figure resembling an inverted chair.

Cassiopeia was the wife of CEPHEUS, king of Ethiopia. She was possessed of great beauty, and boasted herself fairer than Juno, the sister of Jupiter, or the Nereides, a name given to the sea nymphs. This provoked the nymphs of the sea, who complained to Neptune, of the insult. He sent a frightful monster to punish her insolence. It was finally ordained that she should chain her daughter Andromeda, whom she tenderly loved, to a desert rock on the beach, and leave her exposed to the fury of this monster. She was thus left, and the monster approached; but as he was going to devour her, PERSEUS killed him.

Andromeda.—This constellation is south of CASSIOPEIA. It contains 66 stars, three of which are of the third magnitude, viz: Sirrah, in the head; Mirach, in the breast, and Almak, in the feet. They stand nearly in a straight line. ANDROMEDA, the daughter of Cepheus and Cassiopeia, was exposed to be devoured by a Sea Monster, to appease the wrath of Neptune. She was accordingly chained to a rock near JOPPA, (now Jaffa in Syria,) and at the moment the monster was going to devour her, Perseus, who was returning through the air from the conquest of the GORGONS, saw her and was captivated by her beauty. He promised to deliver her and destroy the monster, if her father would give her to him in marriage. Cepheus consented, and Perseus instantly changed the sea monster into a rock, by showing him Medusa's head, which was still reeking in his hand. This fable of Andromeda and the sea monster might mean that she was courted by some monster of a sea captain, who attempted to carry her away, but was prevented by another more gallant and successful rival.

Pegasus, the Flying Horse.—This constellation is represented with wings. It may be known by four stars, which form a regular quadrangle or trapezium. The northeastern of these four stars is in the head of ANDROMEDA. Their names are (α) Markab, (β) Scheat, Algenib, and (α) Sirrah, in the head of Andromeda. According to fable, Pegasus was a winged horse, which sprang from the blood of Medusa, when Perseus cut off her head.

Equuleus, the Little Horse.—This is a small cluster of stars west of the head of the Flying Horse. Only the head is visible. This is supposed to represent the horse which Mercury gave to Castor, and which he named CELERIS.

Delphinus, the Dolphin.—This is a beautiful little constellation, between the Eagle and Equuleus, or Little Horse. It may be distinguished by four stars in the shape of a diamond, with two small stars which form the tail. (See map No. 2, and explanation.)

Sagittarius, the Archer.—This is the tenth constellation in the zodiac. It is situated to the southwest, near the horizon. It may be known by five stars, forming a figure resembling a short handled dipper. It appears turned up, with the handle to the north, and the bowl towards the east. SAGITTARIUS, or Chiron, the son of SATURN, was a twofold being—half man and half horse. This constellation was intended, no doubt, by the ancients to represent the season for hunting; for when the sun enters this sign, the trees have cast their foliage, which enables the hunter to pursue his game to better advantage.

Capricornus, the Goat.—This is the next sign in the ecliptic, east of Sagittarius. There are two conspicuous stars in the head, called Giedi and Dabih. Giedi is the most northern star of the two, and is double. Several other stars may be traced out by reference to the map. The goat was observed by the ancients to be fond of climbing high mountains and lofty precipices, and was therefore considered emblematical of the sun, which, having in this sign reached his greatest southern declination, begins to re-ascend towards the north.

Aquarius, the Water Bearer.—This constellation is represented by the figure of a man pouring out water from an urn, and is north and east of Capricornus. It may easily be traced by reference to the map. The ancient Egyptians supposed the disappearing of Aquarius caused the waters of the Nile to rise by the sinking of his urn in the water.

Pisces, the Fishes.—This is the last sign in the zodiac. This constellation is represented by two fishes, a considerable distance apart, tied by a cord or riband. The stars in this constellation are of the 4th and inferior magnitudes. The probable origin of this sign was from the fact, that when the sun was in it, it was the season when fish were abundant, and easily taken.

Piscis, the Southern Fish.—This constellation is south of Aquarius, and is easily distinguished by the star Fomalhaut, of the first magnitude, with two small stars, which form an equilateral triangle. These three are the only important stars in this constellation. This constellation is supposed to have taken its name from the transformation of Venus into the shape of a fish, when she fled, terrified at the horrible advances of the monster Typhon, who was said to have an hundred heads.

Ursa Major, the Great Bear.—This constellation is directly north, and touches the horizon. The Dipper, which is a part of this constellation, is a little to the northwest of the north star, and is right side up, with the handle to the west. (For explanation, see map No. 1.)

Lacerta, the Lizard.—This is a small constellation near the zenith. It contains a few stars of inferior magnitude.

MAP, FROM JULY 22 TO OCTOBER 31.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be only six stars of the first magnitude visible, the most conspicuous of which will be Deneb, Vega, Altair, and Capella. The other two, Aldebaran and Fomalhaut, being near the horizon, may not be visible unless the atmosphere is very clear.]

STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

CYGNUS, The Swan—(**Deneb** the principal star.)—This star is situated directly west, and about 20° from the zenith. It is in the middle of the Milky-way.

LYRA, The Harp—(**Vega.**)—This star is about 20° west of Deneb.

AQUILA, The Eagle—(**Altair.**)—This star is situated towards the southwest, and about 35° from the zenith.

PISCIS, Southern Fish—(**Fomalhaut.**)—This star is about 10° east of south, and about 15° above the southern horizon—perhaps it will not be visible only when the atmosphere is clear.

TAURUS, The Bull—(**Aldebaran.**)—This star is nearly north-east, and within 10° of the horizon. It will not be visible only when the atmosphere is very clear.

AURIGA, The Charioteer—(**Capella.**)—This star is directly east of the North Star, and about midway to the horizon.

TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

		H.	M.
JULY.....	22	1	56
....	23	1	52
....	24	1	48
....	25	1	44
....	26	1	40
....	27	1	36
....	28	1	32
....	29	1	28
....	30	1	24
....	31	1	20
AUGUST...	1	1	16
....	2	1	12
....	3	1	8
....	4	1	4
....	5	1	—
....	6	12	56
....	7	12	52
....	8	12	48
....	9	12	44
....	10	12	40
....	11	12	36
....	12	12	32
....	13	12	28
....	14	12	24
....	15	12	20
....	16	12	16

		H.	M.
AUGUST...	17	12	12
....	18	12	8
....	19	12	4
....	20	12	—
....	21	11	56
....	22	11	52
....	23	11	48
....	24	11	44
....	25	11	40
....	26	11	36
....	27	11	32
....	28	11	28
....	29	11	24
....	30	11	20
....	31	11	16
SEPTEMBER	1	11	12
....	2	11	8
....	3	11	4
....	4	11	—
....	5	10	56
....	6	10	52
....	7	10	48
....	8	10	44
....	9	10	40
....	10	10	36
....	11	10	32

		H.	M.
SEPTEMBER	12	10	28
....	13	10	24
....	14	10	20
....	15	10	16
....	16	10	12
....	17	10	8
....	18	10	4
....	19	10	—
....	20	9	56
....	21	9	52
....	22	9	48
....	23	9	44
....	24	9	40
....	25	9	36
....	26	9	32
....	27	9	28
....	28	9	24
....	29	9	20
....	30	9	16
OCTOBER...	1	9	12
....	2	9	8
....	3	9	4
....	4	9	—
....	5	8	56
....	6	8	52
....	7	8	48

		H.	M.
OCTOBER...	8	8	44
....	9	8	40
....	10	8	36
....	11	8	32
....	12	8	28
....	13	8	24
....	14	8	20
....	15	8	16
....	16	8	12
....	17	8	8
....	18	8	4
....	19	8	—
....	20	7	56
....	21	7	52
....	22	7	48
....	23	7	44
....	24	7	40
....	25	7	36
....	26	7	32
....	27	7	28
....	28	7	24
....	29	7	20
....	30	7	16
....	31	7	12
.....			
.....			

VISIBLE HEAVENS FROM JULY 22ND TO OCTOBER 31ST

Constellations EAST Rising

Constellations WEST Setting

URSA MAJOR
CANIS VENATICI
LYNX
AURIGA
CAMELOPARDALIS
BOOTES
PERSEUS
CASSIOPEA
POLAR STAR
URSA MINOR
DRACO
CORONA BOREALIS
SERPENS
CEPHEUS
ECLIPTIC
TAURUS
MILKY WAY
CYGNUS
HERCULES
LYRA
TRIANGULUM
ARIES
ANDROMEDA
THE ZENITH
LACERTA
VULPECULA
PEGASUS
PISCES
OPHIUCHUS
DELPHINUS
EQUULEUS
EQUATOR
CELUS
AQUILA
SCUTUM
AQUARIUS
CAPRICORNUS
SAGITTARIUS
SCULPTORIS
PISCIS

STARS VISIBLE

No.		MAG
7	of the 1st	✱
31	2nd	✱
93	3rd	✱
220	4th	✱
383	5th	✱

PRINCIPAL CONSTELLATIONS VISIBLE, FROM NOVEMBER 1 TO JANUARY 20.

Perseus, and Medusa's Head.—This constellation is directly in the zenith, or over head. It contains two stars of the 2d magnitude. The one in the breast of PERSEUS is called Mirzak, or Algenib; the other is ALGOL, in Medusa's head: it is about 15° east of the zenith. This star is remarkable on account of its changeableness. It changes in 4 hours from the 2d to the 4th magnitude. It remains in this condition 18 minutes, when it begins to increase in brightness; and in 4 hours and 40 minutes appears again of the 2d magnitude: in which state it continues 61 hours, when it begins to diminish again. Dr. Herschel attributes its variableness to spots upon its surface like those of the sun, and that it revolves upon its axis.

[*History.*—PERSEUS was the son of Jupiter and DANÆ. He was no sooner born than he was cast into the sea with his mother, and was driven on the coast of one of the islands of CYCLADES. Polydectes, the King of the place, treated them with kindness, and placed them in the care of the Priests of Minerva's Temple. He promised to present the King with the head of Medusa, the only one of the Gorgons who was subject to mortality. They were represented with serpents wreathing about their heads instead of hair; their bodies grew indissolubly together, and their very looks had the power of turning into stone all those on whom they fixed their eyes. Being equipped by the gods, he mounted into the air, conducted by Minerva, and came upon the monsters, who, with the watchful snakes, were asleep, and with one blow cut off her head. Perseus then made his way through the air, with Medusa's head yet bleeding, in his hand, and from the blood which dropped from it as he flew, sprang all those innumerable serpents that have ever since infested the sandy deserts of Lybia.]

Triangulum, the Triangle.—This is a small constellation southwest from Medusa's Head, in the constellation PERSEUS. It may be known by three stars, which form a triangle. This constellation is of recent origin.

Aries, the Ram.—This constellation lies to the southwest, about 30° from the zenith, and may easily be distinguished by three bright stars in the head of the RAM, and nearly in a right line. This constellation twenty-two centuries ago occupied the first sign in the ecliptic; or at that time the constellations of the zodiac and the signs of the ecliptic corresponded to each other: but in consequence of the retrograde motion of the equinoxes, 50″ a year, the constellations of the zodiac and the signs of the ecliptic have been separated from each other, by the falling back of the signs in the ecliptic about 31 degrees: so that the constellation Aries is now in the sign Taurus of the ecliptic; and Taurus in Gemini, and Gemini in Cancer; and so on. This constellation probably received its name from the Chaldean Shepherds, who were in those days the best astronomers, from the fact that their occupation led them to be on the watch during the night, to defend their flocks from the ravages of wild beasts. They observed that when the sun entered this division of the heavens the lambs were with their flocks, or that it was the season for the increase of their flocks—hence the Ram was very appropriately made to represent this sign.

Taurus, the Bull.—This constellation is south, about 30° from the zenith, and will be easily distinguished by the star ALDEBARAN, of the first magnitude, situated in the Bull's eye. There are two very important clusters in this constellation, the Hyades on the head, and the Pleiades on the neck of the Bull. This constellation probably derived its name, as well as the other signs of the zodiac, from some particular *phenomenon* which was apparent at that particular time. It was intended to show that this was the season for the increase of the ox species—hence the name Taurus, or Bull.

Gemini, the Twins.—This constellation is situated a little to the south of east, and may be known by two stars of the 2d magnitude, one in each head of the Twins—their names (α) Castor and (β) Pollux. This sign was originally represented by two goats, and was probably intended to indicate the season for the multiplication of this animal, as well as to show that there were usually two at a birth.

Cancer, the Crab.—This constellation is next east of GEMINI. It contains stars only of the 4th magnitude. It was observed by the Ancients, that the sun, when it enters Cancer, passes sideway along the tropic, without crossing it, which was fitly represented by a crab, which moves sideways.

Orion.—This constellation is southeast of Taurus, and is one of the most conspicuous constellations in the heavens. It contains two stars of the first magnitude. (NOTE.—See description of Map No. 1.)

Canis Minor, the Little Dog.—This constellation is southeast of Gemini. It contains one star of the first magnitude, Procyon, and one of the 3d, MIRZA, in the head of the Dog.

Canis Major, the Great Dog.—This constellation is situated to the southeast, and near the horizon. The principal star is Sirius, the brightest star in the whole heavens. (NOTE.—See explanation to Map No. 1.)

Lepus, the Hare.—This constellation is south of ORION. It contains three stars of the 3d magnitude. It is situated west of the GREAT DOG, which seems to be pursuing it from east to west, owing to the motion of the earth on its axis. The hare is one of those animals which ORION delighted in hunting, and for this reason was made into a constellation, and placed near him, among the stars.

Eridanus, the River Po.—This constellation occupies a large space in the heavens directly south of TAURUS. It will be found difficult to trace it, in all its windings. Its entire height is 130 degrees. It commences near the star Rigel, in the foot of Orion. ERIDANUS is the name of a celebrated river in Italy, now known by the name of the river Po.

Cetus, the Whale.—This constellation occupies the largest space of any in the heavens, and is west of the RIVER PO. As the whale is the chief monster of the ocean, so is it the largest constellation in the heavens. It is considered to be the famous sea monster sent by Neptune to devour ANDROMEDA, because her mother, Cassiopeia had boasted herself fairer than JUNO, or the sea nymphs—but was slain by PERSEUS, and placed among the stars, in honor of his heroic deeds.

Monoceros, the Unicorn.—This constellation is east of ORION, and was made out of the unformed stars of the ancients, which lay scattered over a large space between the two dogs Canis Major and Canis Minor. The Monoceros is a species of Unicorn or RHINOCEROS. It is about the size of a horse, with one horn growing out of the middle of its forehead.

Columba, the Dove.—This constellation is south of the LEPUS, THE HARE. It is so near the horizon that it probably will not be visible. It was introduced among the constellations by Rogu in 1679.

Camelopardalus, the Giraffe.—This constellation was formed by HEVELIUS, in the beginning of the 17th century. It was made up of stars not included in the adjacent constellations, viz: PERSEUS, AURIGA, the head of URSA MAJOR, and the POLE STAR.

MAP, FROM NOVEMBER 1 TO JANUARY 20.

[☞ The Stars and Constellations upon this Map will occupy the exact positions in the heavens as they are laid down on the Map, at the times for observations, as specified in the table. The centre of the Map represents the zenith of New-York, or any place situated upon the parallel of latitude of 41° north. There will be nine stars of the first magnitude above the horizon. The star Vega, in the Harp, being so near the northern horizon, may not be visible. There will be several of the most conspicuous constellations in the whole heavens visible, as well as a considerable number of stars of the first magnitude. The principal constellations are Auriga, Taurus, Orion, Canis Major, and Canis Minor. This is the best season for observation during the year, as the atmosphere is generally more clear than at any other time, and the stars twinkle with a beautiful brilliancy.]

STARS OF THE FIRST MAGNITUDE.

NAMES OF THE CONSTELLATIONS AND PRINCIPAL STARS.

AURIGA, The Charioteer—(**Capella** the principal star.)—This star is about 15° northeast of the zenith.

TAURUS, The Bull—(**Aldebaran.**)—This star is in the Bull's Eye, and is situated about 25° south of the zenith, and 5° east of the meridian.

CYGNUS, The Swan—(**Deneb.**)—This star is situated in the Milky Way, and west of the North Star, about midway to the horizon.

LYRA, The Harp—(**Vega.**)—This star is northwest of the North Star, and close to the horizon—probably not visible.

ORION, Orion—(**Betelgeuse.**)—This star is in the right shoulder of Orion, and situated southeast about 35 degrees.

" (**Rigel.**)—This star is on the left foot of Orion, southeast from Betelgeuse.

CANIS MAJOR, Great Dog—(**Sirius.**)—This star is situated southeast, about 20 degrees above the horizon.

CANIS MINOR, Little Dog—(**Procyon.**)—This star is southeast, and about 40 degrees above the horizon. It is nearly north of Sirius.

LEO MAJOR, Great Lion—(**Regulus.**)—This star is nearly east, and about 15° above the horizon.

TABLE OF THE TIMES FOR OBSERVATIONS.

SHOWING THE DAY AND HOUR OF THE NIGHT WHEN THE STARS OCCUPY THE POSITIONS INDICATED ON THE MAP.

		H.	M.			H.	M.			H.	M.			H.	M.
NOVEMBER..	1	1	28	NOVEMBER	24	11	56	DECEMBER	17	10	24	JANUARY...	9	8	56
....	2	1	24	....	25	11	52	....	18	10	20	....	10	8	52
....	3	1	20	....	26	11	48	....	19	10	16	....	11	8	48
....	4	1	16	....	27	11	44	....	20	10	12	....	12	8	44
....	5	1	12	....	28	11	40	....	21	10	8	....	13	8	40
....	6	1	8	....	29	11	36	....	22	10	4	....	14	8	36
....	7	1	4	....	30	11	32	....	23	10	—	....	15	8	32
....	8	1	—	DECEMBER	1	11	28	....	24	9	56	....	16	8	28
....	9	12	56	....	2	11	24	....	25	9	52	....	17	8	24
....	10	12	52	....	3	11	20	....	26	9	48	....	18	8	20
....	11	12	48	....	4	11	16	....	27	9	44	....	19	8	16
....	12	12	44	....	5	11	12	....	28	9	40	....	20	8	12
....	13	12	40	....	6	11	8	...	29	9	36	....	21	8	8
....	14	12	36	....	7	11	4	....	30	9	32	....	22	8	4
....	15	12	32	....	8	11	—	....	31	9	28	....	23	8	—
....	16	12	28	....	9	10	56	JANUARY...	1	9	28	....	24	7	56
....	17	12	24	....	10	10	52	....	2	9	24	....	25	7	52
....	18	12	20	....	11	10	48	....	3	9	20	....	26	7	48
....	19	12	16	....	12	10	44	....	4	9	16	....	27	7	44
....	20	12	12	....	13	10	40	....	5	9	12	....	28	7	40
....	21	12	8	....	14	10	36	....	6	9	8	....	29	7	36
....	22	12	4	....	15	10	32	....	7	9	4	....	30	7	32
....	23	12	—	....	16	10	28	....	8	9	—	....	31	7	28

VISIBLE HEAVENS FROM NOVEMBER 1ST TO JANY 20TH

BOOTES
HERCULES
LYRA
CANES VENATICI
DRACO
URSA MINOR
CYGNUS
PEGASUS
URSA MAJOR
LEO MINOR
LEO MAJOR
CEPHEUS
LACERTA
CASSIOPEA
CAMELOPARDALUS
ANDROMEDA
LYNX
AURIGA
SEXTANS
HYDRA
GEMINI
PERSEUS
TRIANGULUM
CANIS MINOR
ARIES
PISCES
AQUARIUS
TAURUS
ECLIPTIC
EQUATOR
MONOCEROS
Milky Way
ORION
CETUS
ARGO NAVIS
CANIS MAJOR
LEPUS
ERIDANUS
COLUMBA
Constellations WEST Steering

STARS VISIBLE

Nº		MAG
9	of the 1st	
35	2nd	
92	3rd	
210	4th	
528	5th	

PROBLEMS PERFORMED WITH THE TERRESTRIAL GLOBE.

PROBLEM 1.—*To find the Latitude of any given place.*

RULE.—Bring the given place to the graduated side of the brass meridian, and the degree on the brass meridian over the place is the latitude, which is either north or south.

Q. What is the latitude of New York?

A. About 41 degrees north.

Q. What places have no latitude?

A. All places on the equator.

Q. Find the latitude of the following places:—

London,	Philadelphia,	Boston,	Washington,
Edinburgh,	Rome,	Dublin,	Amsterdam,
Moscow,	Stockholm,	Quito,	Mexico,
Algiers,	Astoria,	Cape of Good Hope,	Halifax,
Norfolk,	Aleppo,	Athens,	Ispahan,
Madras,	Madrid,	Cape Horn,	Cairo,
Prague,	Dantzic,	Teneriffe,	Lisbon,
Tripoli,	Paris,	Lima,	Vienna.

PROBLEM 2.—*To find the Longitude of any given place.*

RULE.—Bring the given place to the brass meridian, and the degree on the equator under the brass meridian, is the longitude. (*Note.*—Longitude is reckoned from the meridian of Greenwich, 180 degrees east and west.)

Q. What is the longitude of New York?

A. 74 degrees west.

Q. What is the longitude of Pekin?

A. 116 degrees east.

Q. Find the longitude of the following places:—

Washington,	Hartford,	Sandwich Islands,	Gibraltar,
Quebec,	Rhodes,	Calcutta,	Constantinople,
Canton,	Havana,	Jerusalem,	Nankin,
Pekin,	St. Petersburgh,	Venice,	Berlin,
Astoria,	Cape Horn,	New Orleans,	Rio Janeiro.

PROBLEM 3.—*To find any place whose latitude and longitude are given.*

RULE.—Bring the given longitude to the brass meridian, and under the given latitude is the place required.

Q. What place is situated in seventy-four degrees west longitude, and 41 north latitude?

A. New York.

Q. What places have the following latitudes and longitudes?

Lat. 42° north, Lon. 71° west.	Lat. 34° south, Lon. 18° east.
Lat. 53° north, Lon. 6° west.	Lat. 41° north, Lon. 72° west.
Lat. 38° north, Lon. 9° west.	Lat. 39° north, Lon. 75° west.
Lat. 46° north, Lon. 75° west.	Lat. 32° north, Lon. 81° west.

PROBLEM 4.—*To find all those places that are in the same latitude or longitude as a given place.*

RULE.—Bring the given place to the brass meridian; then all the places under the meridian have the same longitude; turn the globe round, and all places which pass under the latitude of the place have the same latitude.

Q. What places have nearly the same longitude as New York?

A. Albany, Montreal, Bogota.

Q. What places are in the same latitude?

A. Boston, Madrid, Naples, Constantinople.

Q. What places have the same longitude and latitude as the following places:—

Washington,	London,	St. Petersburgh,	Rome,	Cairo,
New Orleans,	Mexico,	Canton,	Calcutta,	Dublin?

PROBLEM 5.—*To find the difference of Latitude between any two places.*

RULE.—Find the latitude of each place, and note them down; then if both places are on the same side of the equator, subtract the less latitude from the greater: if they are on the opposite sides of the equator, add the latitudes.

Q. What is the difference of latitude between New York and London?

A. New York 41° north, London 51° north; difference 10°

Q. What is the difference of latitude between Washington and Cape Horn?

A. Washington 37° north, Cape Horn, 56° south.—Sum 93.°

Q. Find the difference of latitude between the following places:—

New Orleans and Quebec,	Mexico and Rio Janeiro,
Madrid and Cairo,	Pekin and Botany Bay,
St. Petersburgh and Rome,	Cape of Good Hope and Cape Horn.

PROBLEM 6.—*To find the difference of longitude between any two places.*

RULE.—Find the longitude of each place, and note them down; then, if both places are east or west of the meridian, subtract the less longitude from the greater; but if one is east and the other west add the longitudes.

Q. What is the difference of longitude between New York and New Orleans?

A. New York 74°; New Orleans 90°, west—difference 16 degrees.

Q. What is the difference in longitude between Boston and Rome?

A. Boston 71° west; Rome 12° east—sum, 83 degrees.

If the sum of the longitudes exceed 180 degrees, subtract it from 360 degrees; the remainder will be the difference in longitude; as, Astoria 124° west; Pekin 116° east=240 : 360—240=120° difference in longitude.

PROBLEM 7.—*The hour of the day at any place being given, to find what o'clock it is at any other place.*

RULE.—Bring the place at which the time is given to the brass meridian; set the index to the given hour, then turn the globe till the proposed place comes to the meridian; the index will point to the hour required. If the place required is east of the given place, it is later; if to the west, it is earlier.

Q. When it is noon at New York, what is the time in London?

A. 4 o'clock 56 min.

Q. When it is noon at Washington, what is the hour at New Orleans, Mexico, Quebec, Boston, Astoria, Pekin, Cape Horn, Rome, St. Petersburgh, Moscow, Canton, Dublin? When it is midnight at New York, what is the hour at Paris, Cairo, Calcutta, St. Helena, Gibraltar, Havana, Constantinople, Mexico, Astoria, Nankin, Tunis, Cadiz?

PROBLEM 8.—*The hour of the day being given at any place, to find all places on the globe where it is then noon, or any other given hour.*

RULE.—Bring the place to the brass meridian; set the index to the hour of that place; turn the globe till the index points to the other given hour; then all places under the brass meridian will be the places required.

PROBLEM 9.—*To find the Antœci of any place.*

RULE.—Bring the place to the brass meridian, and find its latitude, then, under the same degree of latitude, on the opposite side of the equator will be the *Antœci.*

PROBLEM 10.—*To find the Periœci of any place.*

RULE.—Bring the given place to the brass meridian, and set the index to twelve; turn the globe till the index points to the other twelve, and under the same degree of latitude will be the *Periœci.*

PROBLEM 11.—*To find the Antipodes of any place.*

RULE.—Bring the place to the brsss meridian, and find its latitude; set the index to twelve, and turn the globe till the index points to the other twelve; then under the same degree of latitude, on the other side of the equator, will be the antipodes.

PROBLEM 12.—*To find the distance in miles between any two places on the globe.*

RULE.—Lay the quadrant of altitude over the two places, so that the division marked 0 will be on one of the places, and it will show the number of degrees between them; which, multiplied by $69\frac{1}{2}$ will give the distance in miles.

PROBLEM 13.—*To find the Sun's Longitude or place in the Ecliptic, and his declination, in any given month or day.*

Rule.—Look for the given day in the circle of months on the wooden horizon, and opposite to it, in the circle of signs, are the sign and degree in which the sun is for that day. Find the same sign and degree in the ecliptic on the surface of the globe; bring the degree of the ecliptic, thus found, to the brass meridian, and the degree of the meridian will be the declination.

Problem 14.—*To find the time at which the Sun rises and sets at any place, the day in the year, and the length of the day and night at that place.*

Rule.—Raise the pole (of the hemisphere in which the place is situated) as many degrees above the horizon as are equal to the latitude of the place; bring the sun's place on the given day, to the meridian, and set the index to 12: bring the sun's place to the eastern horizon, and the index will show the time of the sun's rising; bring the sun's place to the western edge of the horizon, and the index will show the hour of setting. Double the time of the sun's setting, and the length of the day will be had; double the time of the sun's rising, and the length of the night will be had.

Problem 15.—*To find the length of the longest and shortest days and nights at any place on the earth.*

Rule.—If the place is in the northern hemisphere, elevate the north pole till the horizon cuts the brass meridian in the degree corresponding to the latitude of the place; bring the first degree of Cancer to the meridian, and set the index to 12; find the sun's place in the ecliptic, (by problem 13,) and bring it to the eastern edge of the horizon, and the index will show the hour of the sun's rising; double this time, and it will give the length of the longest night. Bring the sun's place to the western edge of the horizon, and the index will show the hour of setting; double this time, and you will have the length of the longest day at that place. If the place is in the southern hemisphere, elevate the south pole to correspond with the latitude of the place; bring the first degree of Capricorn to the meridian, and proceed as above.

Q. What is the length of the longest day and shortest night at New York?

A. Longest day, 14 h. 56 min.; shortest night, 9 h. 4 min.

Problem 16.—*To find those places where the Sun does not rise or set on a given day.*

Rule.—Find the sun's declination on the given day, (by prob. 13,) raise the pole (nearest to the sun's place,) as many degrees above the horizon as are equal to the declination; turn the globe round on its axis, and at all places that do not come above the horizon the sun does not rise on that day; and at all places around the other pole that do not pass below the horizon, the sun does not set on that day.

PROBLEMS PERFORMED WITH THE CELESTIAL GLOBE.

[**Latitude,** on the Celestial Globe, is reckoned 90°, either north or south, on circles of Celestial Latitude, which are at right angles to the ecliptic. (See Diagram, page 44.)

Longitude, on the Celestial Globe, is reckoned on the ecliptic, from the first degree of Aries, eastward, round the globe.

Declination, is reckoned from the equinoctial, either north or south.

Right Ascension, is reckoned on the equinoctial, from the first degree in Aries, eastward, round the globe.]

Problem 1.—*To find the Right Ascension and Declination of the Sun or a Star.*

Rule.—Bring the sun or star to that part of the brass meridian which is numbered from the equinoctial towards the poles: the degree on the brass meridian, over the place, will show the declination; and the number of degrees on the equinoctial, between the brass meridian and the first point of Aries, is the right ascension.

Required—the right ascension and declination of the following stars:

Aldebaran, in Taurus,	Arcturus, in Bootes,
Sirius, in the Great Dog,	Capella, in Auriga,
Vega, in the Harp,	Regulus, in Leo.

Problem 2.—*To find the Latitude and Longitude of a Star.*

Rule.—Place the end of the quadrant of altitude, which is marked 90°, on the north or south pole of the ecliptic, according as the star is north or south of the ecliptic; then move the other end till the graduated edge of the quadrant comes to the star. The number of degrees on the quadrant, between the ecliptic and the star, is the latitude; and the number of degrees on the ecliptic, reckoned eastward, from the first point of Aries to the quadrant, is the longitude.

Example.—*Required,* the latitudes and longitudes of the following stars:—

Aldebaran, in Taurus. *Ans.* Latitude 5° 28′ S.; longitude, 2 signs 6° 53′, or 6° 53′ in Gemini.

Deneb, in the Swan,	Altair, in the Eagle,
Antares, in Scorpio,	Rigel, in Orion,
Fomalhaut, in the S. Fish,	Pollux, in Gemini.

Problem 3.—*The declination and right ascension of a Star, the Moon, a Planet, or a Comet, being given, to find its place on the globe.*

Rule.—Bring the given degrees of right ascension to that part of the brass meridian which is numbered from the equinoctial towards the poles; then under the given declination on the brass meridian you will find the star or planet.

Q. What stars have the following right ascensions and declinations?

Right Ascension.	Declination.	Right Ascension.	Declination.
76° 14′	8° 27′ S.	86° 13′	44° 55′ N.
83 6	34 11 S.	99 5	16 26 S.
25 54	19 50 N.	11 11	59 38 N.
53 54	23 29 N.	46 32	9 34 S.

Problem 4.—*The latitude and longitude of the Moon, a Star, or a Planet, being given, to find its place on the globe.*

Rule.—Screw the quadrant of altitude on the pole of the ecliptic, and place the other end on the given degree of longitude in the ecliptic; then, under the given latitude, on the graduated edge of the quadrant, you will find the star, or place of the moon or planet.

Q. What stars have the following latitudes and longitudes?

Latitudes.	Longitudes.	Latitudes.	Longitudes.
16° 3′ S.	2ˢ 25° 51′	10° 4′ N.	3ˢ 17° 21′
22 52 N.	2 18 57	21 6 S.	11 0 56
5 29 S.	2 6 53	12 3 S.	1 11 25
44 20 N.	7 9 22	0 27 N.	4 26 57

Problem 5.—*The latitude of a place, the day and hour being given, to place the globe in such a manner as to represent the heavens at that time, in order to point out the situations of the constellations and remarkable stars.*

Rule.—Elevate the pole for the latitude of the place, and set the globe due north and south by a meridian line; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index to 12. If the time be afternoon, turn the globe westward; if in the forenoon, turn the globe eastward, till the index points to the given hour. The surface of the globe then represents the appearance of the heavens at that time and place.

Problem 6.—*To find the distance of the Stars from each other, in degrees.*

Rule.—Lay the quadrant of altitude over any two stars, so that the division marked 0 may be on one of the stars; the degrees between them will show their distance, or the angle which these stars subtend, as seen from the earth.

Example.—What is the distance, in degrees, between the two stars Vega and Altair? *Ans.* 34 degrees.

Also, between Regulus and Procyon,
" " Aldebaran and Sirius,
" " Arcturus and Spica,
" " Capella and the North Star?

GLOSSARY,

OR EXPLANATION OF ASTRONOMICAL TERMS.

ABERRATION.—An apparent annual motion in the fixed stars, occasioned by the velocity of light combined with the real velocity of the earth in its orbit.

Absorbent Media —Substances either solid, liquid, or fluid, which imbibe the rays of light and heat.

Acceleration.—An increase in the rapidity of the motion of a moving body. The motions of the planets are accelerated from their aphelion to their perihelion.

Acronycal.—A star is said to rise or to set acronycally when it rises or sets at the instant of sunset.

Æriform.—Having the form of air.

Aerolite.—A meteoric stone.

Air or Atmosphere.—A transparent, invisible, elastic fluid, surrounding the earth, in which we move and breathe.

Altitude.—The height of an object above the horizon.

Amphiscii.—A name applied to the inhabitants of the torrid zone, because within the year, their shadows, at noon, are cast both north and south.

Amplitude.—The distance which a heavenly body rises from the east, or sets from the west point of the horizon.

Analemma.—A figure on the artificial globe, drawn from one tropic to the other, on which is marked the sun's declination for each day in the year.

Angle.—The corner or opening between two lines that meet. A right angle contains 90 degrees, and is formed by one line falling perpendicularly upon another. An acute or sharp angle is less than a right angle. An obtuse or blunt angle is greater than a right angle. The measure of an angle is always an arc.

Angle of Position of a Double Star.—The angle which a line joining the two stars makes with one parallel to the meridian.

Angular Distance.—The distance between two objects, which is indicated by the angle, made by straight lines drawn to them from a given point.

Annual Equation —A periodical inequality in the motion of the moon, or a planet, going through its changes in a year.

Annual Revolution of the Earth.—Its yearly revolution round the sun.

Annular.—Having the form of a ring.

Anomaly.—The sun's angular distance from the apogee, or the earth's from aphelion.

Antarctic Circle —A circle round the south pole, 23° 28′ from it.

Antipodes.—Those who live on directly opposite sides of the earth.

Antœci.—Those who live in equal latitude on directly opposite sides of the equator.

Aphelion.—The point in a planet's orbit which is farthest from the earth.

Apogee.—The point of the orbit of the moon or a planet farthest from the earth.

Apparent Diameter.—The diameter of a body as seen from the earth.

Apparent Motion.—The motion of the heavenly bodies as viewed from the earth.

Apparent Time.—The time shown by the sun, as indicated by a dial.

Apsis.—The point of an orbit which is at the greatest or least distance from the centre of motion. The former is called the higher apsis; the latter the lower apsis. The two together are termed the apsides, and a line uniting them is called the apsis line, or line of the apsides.

Aquarius.—The eleventh sign of the ecliptic.

Arc.—Any part of the circumference of a circle.

Arctic Circle —A circle round the north pole, 23° 28′ from it.

Areas.—In astronomy, they are the spaces passed over by the radius vector of a celestial body.

Aries.—The first sign of the ecliptic. Its first point is at the vernal equinox.

Argument.—A quantity by which another quantity or equation is found.

Ascensional Difference.—The difference between right and oblique ascension.

Aspect.—The appearance of the heavenly bodies with respect to position, angular distance, &c.

Asteroids.—Eight small primary planets, whose orbits are between those of Mars and Jupiter. Their names are Vesta, Astræa, Juno, Ceres, Pallas, Hebe, Iris and Flora. Some suppose them to be fragments of a planet, burst by some internal explosion.

Astronomical Time.—Time reckoned from the noon of one day up to 24 hours, to the noon of the next day. It consequently is made up of the last 12 hours of the same civil day, and the first 12 hours of the next civil day.

Atmosphere.—The air that surrounds the earth.

Attraction.—The power of one body to draw another towards it.

Austral.—Southern.

Aurora.—The morning, or the morning twilight.

Aurora Borealis, or Northern Lights.—A luminous appearance in the heavens, usually seen in high latitudes, and so named from its frequent resemblance to the morning dawn.

Axis of Rotation.—The line around which a revolving body turns.

Axis of an Ellipse.—The major axis is the greatest diameter. The minor axis is the least diameter.

Azimuth.—The distance of a heavenly body east or west of the meridian, which is indicated by the angle between the meridian and the vertical circle passing through the body.

Azimuth, or Vertical Circle —A great circle in the heavens, passing through the zenith and nadir, and cutting the horizon at right angles.

Binary System of Stars.—Two stars revolving about each other.

Bissextile, or Leap Year.—Every fourth year, in which February has 29 days.

Body.—In astronomy this term is applied to any one of the celestial orbs.

Calendar.—A term applied to the Almanac, or the divisions of time of which it treats.

Calendar Months.—The months as laid down in the almanac.

Cancer.—The fourth sign of the ecliptic.

Capricorn.—The tenth sign of the ecliptic.

Cardinal Points.—The east, west, north and south points of the horizon.

Centrifugal Force.—The force which urges a revolving body forward in its orbit, or tends to carry it away from the centre of motion.

Centripetal force —The force which draws a revolving body towards the centre of motion.

Chord —A straight line from one end of an arc to the other.

Circle —A figure bounded by a curve line, every part of which is equally distant from the centre. A great circle is one whose plane divides a globe into two equal parts called hemispheres; a small circle is one whose plane divides a globe into unequal parts.

Circle of Declination —The circle where the plane of the meridian meets the heavens

Circle of Illumination.—The circle that divides the enlightened from the dark hemisphere.

Circumference.—The boundary of a circle. The circumference of every circle is supposed to be divided into 360 equal parts, called degrees; each degree into 60 equal parts, called minutes; and each minute into 60 equal parts, called seconds.

Circumpolar Stars.—Those stars which revolve around the pole without passing below the horizon.

Clouds.—Vapor, in the atmosphere, condensed into small drops of water, and thus rendered visible.

Colures.—Those two meridians which pass through the equinoctial and solstitial points of the ecliptic, called the equinoctial and solstitial colures.

Comet.—A body with a luminous train or tail, moving around the sun in a very elongated orbit.

Complement of an Arc or Angle —What it wants of 90 degrees.

Concave.—Hollowing in a circular manner.

Concentric Circles.—Circles having the same centre.

Cone.—A solid with a circular base, and tapering equally upwards to a point.

Conjunction.—Two heavenly bodies are in conjunction when they have the same longitude. A planet is in inferior conjunction when it is between the earth and sun; in superior conjunction when it is beyond the sun The inferior planets only have inferior conjunction, but all have superior conjunction

Constellations —Groups of stars to which the names of men and animals were anciently given. The whole starry firmament is divided into such groups.

Convex.—Rounding out in a circular manner.

Cosmical.—The rising or setting of a star is said to be cosmical, when it rises or sets at the moment of sunrise.

Cube.—A square solid of six equal sides.

Culminate.—To pass the highest point of the diurnal arc, which is at the meridian.

Culmination.—The passing over the meridian, or point of highest altitude.

Cycle.—A period of time in which the same phenomena or circumstances of a body begin to occur again in the same order.

Cycle of the Moon, or Metonic Cycle.—A period of 19 years; after which the changes of the moon return to the same days of the month (when five leap years are included,) as on the same year of the preceding cycle, or 19 years before.

Cycle of the Sun.—A period of 28 years; after which the same days of the month return to the same days of the week; and the sun's place, to the same degrees and minutes of the ecliptic, as on the same year of the preceding cycle.

Cycle of a Planet.—A period during which a planet passes through its various positions with respect to the sun and earth.

Cylinder.—A round figure or solid of equal size from end to end.

Cylindrical.—Having the form of a cylinder.

Declination.—The angular distance of a heavenly body, north or south, from the equinoctial.

Degree.—One 360th part of the circumference of a circle.

Diagonal.—A line drawn from corner to corner of a four sided figure.

Dial.—An instrument showing the hour of the day, by the shadow of the sun.

Diameter.—A straight line passing through the centre of a figure, and terminated both ways by its sides or surface. The longest and shortest diameters of an ellipse are called the transverse and conjugate diameters.

Dichotomized.—Divided into equal and similar parts, as the disc of the moon at quadrature.

Digit.—One-twelfth part of the apparent diameter of the sun or moon

Direct motion of a Planet.—Apparent motion from west to east, according to the order of the signs.

Disc.—The apparent surface of a heavenly body.

Diurnal Arc.—The arc described by a heavenly body from its rising to its setting.

Diurnal Revolution of the Earth.—Its daily rotation on its axis, from west to east.

Dominical Letter.—The letter in the calendar against Sunday; the first 7 letters of the alphabet being applied to the first 7 days of the year.

Dionysian Period.—A period of 532 years; found by multiplying the cycles of the sun and moon.

Earth.—The globe on which we live.

East.—The direction in which the sun rises at the equinoxes.

Eccentric.—Deviating from the centre; irregular.

Ecccentric Circles.—Those that are wholly or partially included in each other, but have different centres.

Eccentricity.—The distance from the centre of an ellipse to either of its foci.

Ecliptic.—The circle, where the plane of the earth's orbit meets the heavens.

Egress.—The act of going out.

Element.—Fundamental principle; quantity by which something else is found.

Elevation.—Height or altitude.

Ellipse.—An oval; a figure made by the oblique section of a cone.

Elongation.—The angular distance of a planet from the sun, or the difference of their celestial longitude.

Emersion.—The act of rising out of something, or re-appearing.

Epact.—The age of the moon at the commencement of the year.

Epicycle.—The curve described by a point of one circle, revolving upon another circle.

Epoch or Era.—A particular time, from which events are reckoned.

Equation.—A quantity to be applied to *mean* time, place, or motion, in order to find the *true*.

Equator.—A great circle, whose plane is perpendicular to the earth's axis.

Equinoctial or Celestial Equator.—The circle, where the plane of the equator meets the heavens.

Equinoctial Points.—The points where the equinoctial cuts the ecliptic, or the first points of Aries and Libra.

Equinox.—The time when the sun enters either of the equinoctial points. The vernal equinox occurs in March, the autumnal in September.

Evection.—A periodic inequality in the motion of the moon.

Firmament.—The heavens, or orb of fixed stars.

Fixed Stars.—Those stars which preserve the same situation with respect to each other.

Foci.—The plural of focus; the two points round which an ellipse is drawn.

Fogs or Mist.—Vapor, condensed into minute drops of water, as in clouds.

Frustum.—What remains of a regular figure after a piece is cut off by a plane parallel to its base.

Galaxy or Milky Way.—A luminous zone in the heavens, composed of an immense number of fixed stars

Geocentric.—As seen from the earth, or the earth being the centre.

Gibbous —The shape of the illuminated part of the moon, when more than half and not the whole of its disc is visible.

Globe.—A sphere, ball, or round body. Artificial globes of two kinds are made; the terrestial, to represent the earth; and the celestial, to represent the heavens.

Golden Number —The number of years in the cycle of the moon since the epact was nothing

Gravitation or Gravity.—The attraction or power which draws all bodies towards each other. Also, its effect, as weight, caused by the earth's attraction.

Hail.—Drops of rain, frozen while falling

Harvest Moon.—The full moon nearest the autumnal equinox.

Heliacal.—The heliacal rising or setting of a star takes place, when it rises a little before or sets a little after the sun.

Heliocentric.—As seen from the sun, or the sun being the centre.

Hemisphere.—Half a sphere or globe.

Heteroscii.—A name given to the inhabitants of the two temperate zones, because at noon those in the northern always have their shadows in an opposite direction to those in the southern.

Horizon —The visible or sensible horizon is the circle where the sky and earth appear to meet. The rational horizon is parallel to the visible, and its plane divides the earth into upper and lower hemispheres. It is represented on the artificial globe by the wooden horizon. The circle where its plane meets the heavens is called the celestial horizon.

Horizontal.—Level or parallel to the horizon

Hour Circle.—A small circle, on the globe, near the north pole, having on it the hours of the day.

Immersion.—The act of plunging into something, or disappearing.

Inclination.—Angle. A position forming an acute angle.

Index.—A movable hand on the globe, to point out the time on the hour circle.

Ingress.—An entrance.

Intercalation.—The insertion of an extra day in the calendar, as the Bissextile.

Julian Period.—A period of 7,980 years, found by multiplying together the cycles of the sun and moon, and the Roman Indiction.

Julian Year.—A period of exactly 365¼ days.

Latitude on the Earth.—The distance of a place north or south of the equator

Latitude in the Heavens.—The angular distance of a heavenly body from the ecliptic.

Leap Year.—Every fourth year, in which an extra day is added to the calendar.

Leo.—The fifth sign of the ecliptic.

Libra —The 7th sign of the ecliptic.

Libration of the Moon.—A periodical oscillation of her disc.

Limb.—The curved edge of the sun or moon's disc.

Line.—That which has length but no breadth.

Longitude on the Earth.—Distance east or west of the first meridian.

GLOSSARY, OR EXPLANATION OF ASTRONOMICAL TERMS, (CONTINUED.)

Longitude in the Heavens.—The angular distance of a heavenly body, measured on the ecliptic eastward, from the first point of Aries.

Luminous.—Capable of shining without light from another body.

Lunar Distance.—The angular distance of the centre of a celestial object from the centre of the moon.

Lunar Month.—The time from one new moon to the next.

Lunation.—The average time of the lunar month

Mariner's Compass.—An instrument with a magnetic needle, to point out the horizontal direction.

Mass.—The quantity of matter in a body.

Mean.—Average; applied to distance, longitude, motion, place, time, &c.

Meridian of a Place.—A great circle passing through the place and the poles of the earth. The first meridian is the one from which longitude is reckoned. The brazen meridian is that in which the artificial globe turns.

Meteor.—A transitory object in the air. Falling stones are often called meteorites.

Minute.—One 60th part of a degree; also one 60th part of an hour.

Moon's Southing.—The time when the moon comes to the meridian of a place.

Nadir.—A point directly opposite to the zenith, or beyond the centre of the earth.

Neap Tide.—The least flood and ebb tide.

Nebulæ.—Clusters of Stars, or other causes of the luminous appearances in the heavens.

Nocturnal Arc.—The arc described by a heavenly body from its setting to its rising.

Nonagesimal Degree.—The highest point of the ecliptic above the horizon

Node.—The point of the moon's or a planet's orbit that is cut by the plane of the ecliptic. There are two nodes, one on each side of the centre of motion; and a line joining them is called the line of the nodes. The place where the body passes to the north of the ecliptic is called the ascending node; the other the descending node.

New Style.—The reckoning of time established by Gregory XIII., and now generally adopted.

North.—That point of the horizon which is directly towards the northern pole.

Nucleus of a Comet.—The part of its head which appears to be dense.

Nutation.—A variation in the direction of the earth's axis, caused by the attraction of the moon on the protuberant matter at the terrestrial equator

Oblique.—Forming an acute or obtuse angle; not perpendicular.

Oblique Ascension.—That degree of the equinoctial which rises with a body in an oblique sphere.

Oblique Descension.—That degree of the equinoctial which sets with a body in an oblique sphere.

Obliquity.—Deviation from parallelism and from perpendicularity.

Obliquity of the Ecliptic.—The angle formed by the equinoctial with the plane of the ecliptic.

Occidental.—To the west, where the heavenly bodies appear to descend.

Occultation.—The eclipse of a star or planet by the moon or by another planet.

Octant.—Forty-five degrees distant, or the eighth part of a circle.

Old Style.—That reckoning of time which makes *every* fourth year a leap year.

Opake.—Not luminous or transparent

Opposition.—Two bodies are in opposition when they are on opposite sides of the earth.

Orbit.—The path in which one body moves round another.

Oriental.—Towards the east, where the heavenly bodies rise.

Parallax.—The difference of the place of a body, as seen from different points of view Diurnal parallax is the difference between the apparent and true place of a body. Horizontal parallax is the diurnal parallax of a body in the horizon. Annual parallax is the difference of the apparent place of a body, as seen from different parts of the earth's orbit.

Parallactic Motion.—Angular motion sufficiently great to be perceived.

Parallel Lines.—Those continued in the same direction, at the same distance from each other. Parallels of altitude, declination, and latitude, are small circles parallel to the horizon, equinoctial, and equator.

Penumbra.—A partial or imperfect shadow.

Perigee.—The point nearest the earth, in the orbit of the moon or a planet.

Perioeci.—Those who live in equal latitude on opposite sides of the pole.

Perihelion.—The lower apsis, or point nearest the sun, in a planet's orbit.

Periodic Inequality.—An irregularity in the motion of a celestial body, requiring a comparatively short time for its accomplishment.

Periodic Time.—The time in which a heavenly body revolves around its centre of motion.

Periscii.—A name given to the inhabitants of the frigid zone, because their shadows turn all round them in one day

Perpendicular.—Making a right angle with some line or surface.

Perturbations.—Irregularities in the motions of bodies, from some disturbing cause.

Phases.—Different appearances of the moon and planets as they are differently illuminated.

Phenomena.—Appearances in the works of nature. (Singular Phenomenon.)

Physical.—Belonging to material nature.

Pisces.—The 12th sign of the ecliptic.

Plane.—Length and breadth without thickness. The plane of a circle is the surface contained within it, and continued out of it on all sides, indefinitely, to the heavens.

Planet.—An opake body revolving around the sun The secondary planets revolve around the primary planets, as well as around the sun. Those planets nearer to the sun than the earth is, are called inferior; those more distant are called superior.

Pleiades.—The seven stars in the constellation Taurus.

Point.—That which has position but no magnitude.

Polar Circles.—Small circles drawn around the poles, 23½ degrees from them.

Polar Distance.—Angular distance from the pole, measured on a circle of declination.

Poles.—The terrestrial poles are the extremities of the earth's axis. The celestial poles are the points where the earth's axis, if produced, would meet the heavens.

Pole Star.—A star of the second magnitude, near the north pole of the heavens.

Pointers.—Two stars in the great bear, that serve to point out the pole star.

Precession of the Equinoxes.—A retrograde motion, on the ecliptic, of the equinoctial points, caused by the action of the sun and moon upon the protuberant matter at the earth's equator.

Quadrant.—Ninety degrees, or a quarter of a circle. An instrument to measure angles.

Quadrature.—The position, a quarter of a circle from the sun.

Quadrilateral Figure.—One that has four sides

Quartile.—Ninety degrees distant from each other.

Quiescent.—At rest; not in motion.

Radiation.—An emission of rays.

Radius.—A straight line from the centre of a circle or sphere to its circumference.

Radius Vector.—A straight line between a planet and the sun, or centre of motion.

Rain.—Drops of water falling from the clouds.

Reflection.—The turning back of rays of light or sound from a surface.

Refraction.—The breaking or bending of a ray of light in passing through media of different densities.

Repulsion.—The property by which bodies recede or fly from each other

Retrograde Motion of a Planet.—Apparent motion from east to west, contrary to the order of the signs.

Revolution.—Motion from a point round to the same again.

Right Ascension.—The distance east on the equinoctial from the first point of Aries.

Right Line.—A straight line; a direct course.

Roman Indiction.—A period of 15 years.

Rotation.—The motion of a body round its axis.

Satellite.—A moon, or secondary planet.

Scorpio.—The eighth sign of the ecliptic.

Secondary Circles.—Such as are in planes that are perpendicular to those circles of which they are the secondaries.

Sector of a Circle.—Space enclosed by two radii and an arc, less than a semicircle.

Secular Inequalities.—Variations in the motions of the heavenly bodies, requiring many ages for their accomplishment.

Segment.—Any part of the surface of a circle cut off by a cord.

Semicircle.—Half a circle Half of the circumference, or an arc of 180 degrees.

Sidereal Day.—The time included between two consecutive transits of the same star at the same meridian. This period is invariably of exactly the same continuance; and it is the only one in nature, with which we are acquainted, that is so Hence it forms a perfect standard measure, by reference to which all portions of time may be ascertained Astronomical clocks are made to show sidereal time. It may likewise be observed that our standard measures of length, capacity, and weight, depend upon the equable rotation of the earth on its axis, as they are referred to the length of a pendulum beating seconds of mean time.

Sign.—Thirty degrees, or the 12th part of a circle. The ascending signs of the ecliptic are those in which the sun's meridian altitude is daily increasing.

Snow.—Water frozen while in the form of clouds, mist, or fine rain, which then falls gently to the earth

Solar Day.—The time from one noon to the next, is the apparent, and the average time of that period, the mean, solar day.

Solar System.—The sun, with its planets and comets arranged regularly, in their several positions.

Solstices.—The times at which the sun is in the solstitial points. When the sun is at the summer solstice all places in the northern hemisphere have their longest day. These days vary in length from 12 hours at the equator to 24 at the arctic circle, and in the frigid zone they increase from 24 hours at the arctic circle to 6 months at the polo, where there is but one day and night during the year. At the same time all places in the southern hemisphere have their *shortest* day, These vary from 12 hours at the equator to nothing at the antarctic circle, where the sun does not rise above the horizon. The length of the *days* in south latitude corresponds to the length of the *nights* in north latitude; and the length of the *nights* in south latitude corresponds to the length of the *days* in north latitude When the sun is at the winter solstice, this condition of things is reversed, and the southern hemisphere presents the same phenomena, with respect to the sun, as does the northern when the sun is at the summer solstice.

Solstitial Points.—The points of the ecliptic which are farthest from the equinoctial.

South.—That point of the horizon which is directly opposite to the north pole

Sphere.—A globe or ball. A solid which has every point of its surface equally distant from its centre. Also, the concave expanse of the heavens that surrounds the earth The sphere has three positions, right, oblique and parallel Those who live at the equator have a right sphere, all the circles of daily motion rising directly above, and descending directly below the horizon Those who live between the equator and poles have an oblique sphere, all the circles of daily motion being oblique to the horizon. Were any one at either of the poles he would have a parallel sphere, all the circles of daily motion being parallel to the horizon On the artificial globe a right sphere is represented by placing both poles in the horizon; an oblique sphere by raising one pole a little and depressing the other; a parallel sphere, by bringing one pole to the zenith and the other to the nadir.

Spherical.—Having the form of a sphere.

Spheroid.—A solid resembling a sphere If the polar diameter be the least, it is called an oblate spheroid; if it be the greatest, it is called a prolate or oblong spheroid.

Spring Tide.—The greatest flood and ebb tide

Stationary,—A term applied to the apparent motion of a planet, when its real motion, combined with that of the earth, causes it to remain at the same point in the heavens.

Supplement of an arc or angle.—What the arc or angle wants of 180 degrees.

Surface.—That which has length and breadth, but no thickness.

Synodic Month.—A complete lunation, or from one new moon to another; it being 29 days, 12 hours and 44 minutes.

Syzygies.—The points in the moon's orbit where she is new or full.

Taurus.—The second sign of the ecliptic.

Tide.—The rising and falling of the waters of the ocean. The rising of the water is called flood tide; the falling, ebb tide.

Transit.—The passage of a body across the meridian of a place. The transit of Mercury and Venus usually means their apparent passage across the sun's disc.

Trapezium.—A figure bounded by four unequal sides.

Triangle.—A figure bounded by three lines, or sides. An equilateral triangle has three equal sides; an isosceles, only two; a scalene triangle has three unequal sides. A triangle is called a right, obtuse, or acute angled triangle, according as it has a right, obtuse, or three acute angles.

Tropic of Cancer.—A small circle, 23° 28′ north of the equator, and parallel to it.

Tropic of Capricorn.—A small circle, 23° 28′ south of the equator, and parallel to it.

Tropical Year.—The period between the consecutive returns of the sun to the same tropic or solstice.

True Distance.—The actual distance of a body from the sun, or of a satellite from its planet.

True Place of a Planet.—The place where it would appear to be, if seen from the centre of the earth, or centre of motion.

Twilight.—The faint light of the sun before sunrise and after sun-set.

Umbra.—A dark or total shadow.

Universe.—The whole material creation. It has been improperly applied sometimes to large clusters of stars.

Vapor.—Water in an æriform state—steam.

Vertex.—The head, top, or summit.

Vertical.—The direction of the plumb-line.

Vertical Plane.—A plane passing through the plumb-line, consequently perpendicular to the horizon

Vertical Circle.—A circle in a vertical plane, passing through the zenith and nadir, and cutting the horizon at right angles

Virgo.—The 6th sign of the ecliptic.

Waning.—Declining in power, or decreasing in light.

West.—That direction in which the sun sets when in the equinoxes.

Wind.—Air in motion. The trade winds blow steadily to the westward, in the Atlantic and Pacific oceans, between the tropics. The monsoons, or shifting trade winds, in the Indian ocean, blow part of the year one way, and the other part in an opposite direction. The winds beyond the 40th degree of latitude are all variable. In the torrid zone, near the sea, breezes blow from the land in the morning and from the sea in the evening.

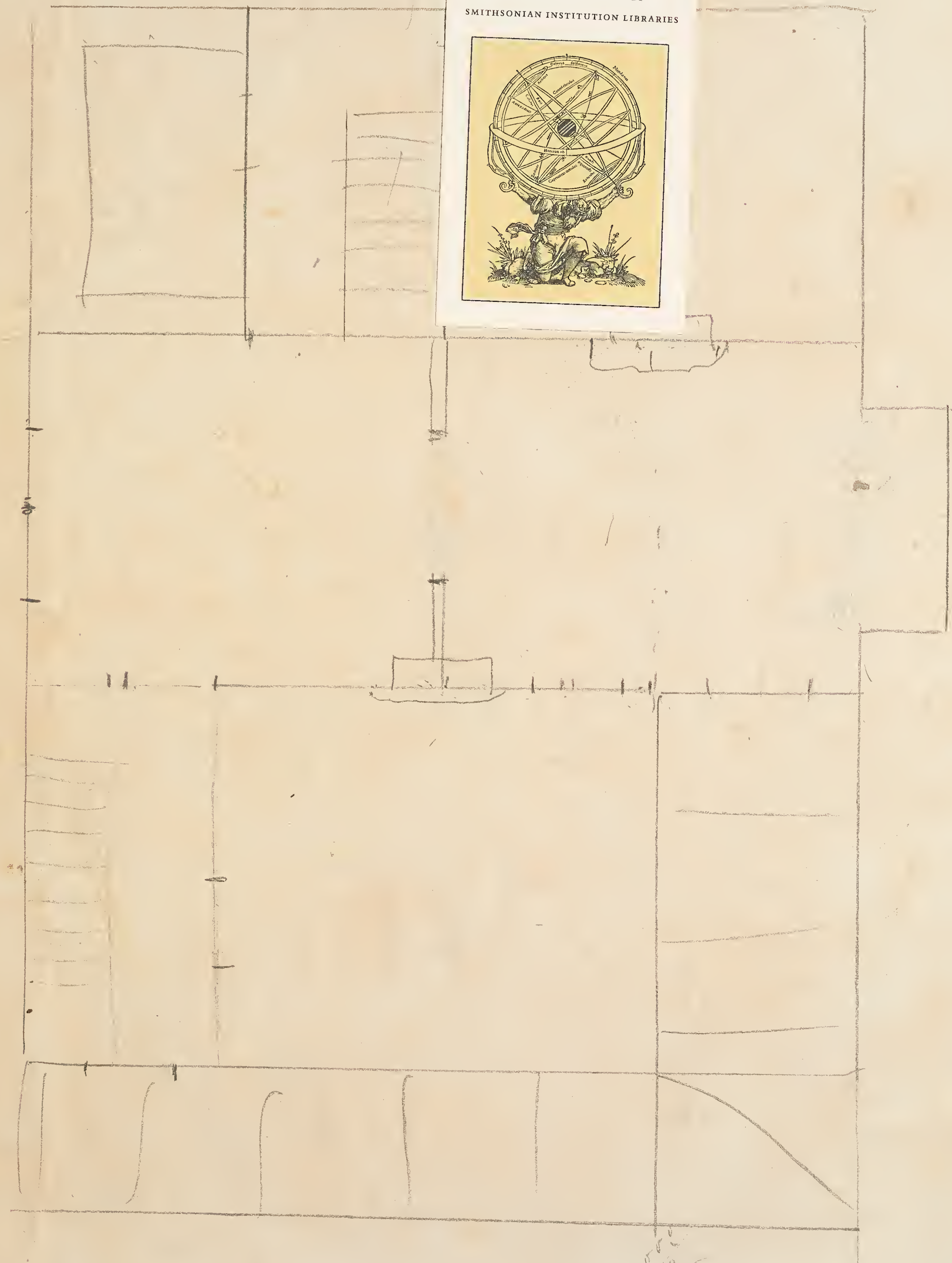
Year.—A solar or tropical year is the period from the departure of the sun from the summer solstice, to its return to it again. Its length is 365 days, 5 hours, and nearly 49 minutes. The sidereal year, which is the period between the departure and return of the sun to a fixed star, is about 17 minutes longer. The anomalistical year is the time from the sun's leaving his apogee till he returns to it, and is 365 days, 6 hours, and about 14 minutes.

Zenith.—The point in the heavens directly over head.

Zenith Distance.—The angular distance of a heavenly body from the zenith, measured on a vertical circle.

Zodiac.—A space or belt in the heavens, 16 degrees broad, (8° on each side of the ecliptic,) in which are the orbits of all the planets except a part of the asteroids.

Zone.—A belt or girdle on the earth's surface, formed by circles parallel to the equator There are five zones; the torrid, two temperate, and two frigid, formed by the tropics and polar circles



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